EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

APRIL 7, 1981

#### Oceanography

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CA 9.20117

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J. Geophys, Ren., Green, Paper (CG42)

VOL. 82, NO. 14, PAGES 137-152

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A SPALLON MORTEXANTARD CURRENT IN THE MORTH INCITIC

5. Renyoe (Scripps Inalituation of Ocasoography, 1-17), is Jolia, California 930911

5. Propose (Scripps Inalituation of Ocasoography, 1-17), is Jolia, California 930911

5. personance large-scale longitudinal maximum is particulated in the sentent Morth Pasilis is unpicals by a caramant circulation. One part of the sirculation causaters of a northeastrant current measure the sentence, which estands diagonally from loss in the sentence which estands diagonally from loss in the sentence of the wastern side on mid-initudes and he wastern side of the basis, and a southwastern or the wastern side on mid-initudes and he asserted for the orthograph of the orthograph of the circulation consists of mid-letitude asserted and low letitude esseved surfaces surface. The other part of the circulations of cultifude osastrand and in the sentence of the sentenc

Affo distributions and water masses
fixesistives in the classification by the paper of the paper conjugation is temperature/sailinity relationship slong the sais of the Anterett Circumpolar Current. Harked differences to the CDP potential responsiture/sailinity properties after from the CDP potential responsiture/sailinity properties after from the CDP potential responsiture/sailinity properties after from the content of the CDP potential the South Atlantic. However, the varrical density disast treated near large and sail affected the releast of water is and easy untare density sless target and sail and the releast and frame appears responsible for this release and activate and responsible for this release the southing appears responsible for this release the southing activate and sail milit invarience, he between the southings for ash of the South Affects and is represented by the signeture of finis is lated airing. This finestrealers of som-internal wars origin is perticularly evident in the southwatern Aspeatine Bealo, where 3'0 temperature layers of the Southing of the MADW/CDP configures, between 1500 and 200 writical safes are found at the depth of the MADW/CDP configures, between 1500 and 200 writical to 25% a wartical wavelength band is eakqualized for the finestive are southwart folias Cason. The imperature are southwart folias Cason. The imperature date from the southwart folias Cason. The impension set he control and Basters Atfanic and the Boothwart folias Cason. The imperature-gradient variance date from the Argentine south head for the Argentine Basts is shoon used to action the Island beart flux in the MADW/CDP company (1977). The sailer lateful office southing are small to lateral head flux in the MADW/CDP superity of each of a gradient flux in the MADW/CDP company (1977). The sailer lateral defined of the configuration of the sailer of the flux in the MADW/CDP company (1977). The sailer lateral definition of the control of the sailer of the flux in the MADW/CDP company (1977). The sailer lateral flux in the MADW/CDP company (1977). The sailer lateral flux is the control of the control of t

4765 Surface waves, tides and soe level
(MPRAGRAVITY EXPANY IN THE SURP 20ME
R. Holman [oragoe State University, Corvalite,
Gregon, 97311)
The saries of rolocity spectre have been obtaloed eight the surf some an Martinique Sach,
Nova Socia at different stages of the tide and
for verying incident wave conditions. The spectre show significars attruture, to the form of
peaks and raileys, in the infragravity band
1.002-05 ha) but the frequencies of the features
rary scoushat with the stage of the tide and ave
nos consident between instruments. Analysis is
antived out is sarms of a spectral twenformation
(the energy spectrum within would be observed at
an offebors forerusent if the shoreline supilitude
spectrum was whits with unit spectral energy deneity). The transformation duplicates its sajor
spectrum is relatively secoth judgicy bind, indicating that the squivalout shoreline supflude
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spectrum is relatively secoth judgicy bind, indicating that the squivalout shoreline supflude
spectrum is relatively secoth judgicy bind, indominantly associated with free waves, not forced
oscillations. The imagehors valuelity spectra
forced nextilations ere denimant. The wave smsrgy acco in the members valuelty spectra could
than be appletized in tarms of atanding forident
waves my the superposition of many edge wave
modes including high modes. Consideration of
adge wave dynamics indicates that the latter
rase might be expoured on east count jof North
Assitice) beaches where Atliectic foldent wavel
typically shoe to bodorare directions spread. rame might be expoured on east const [of North Assirical baseless where Atlantic facilists whill injuically shoe a moderar directional appred-Comparison of infragranty emergy during high and in intident sondlines shows that infragrantly sarely sarely to become dominant during storms. However, this observation is from data taken within the surf some where increases in incident amplitude ere limited by the breshing process. There is reason to believe the the opposite observation might have been made if the data had compared more representative variables such as the offshore incident amplitude and the shoraling adapt were emplitude.

J. Geophys. Ras., Gress, Paper 100114

A780 Underwater Sound
SCATTERING FERN VOLUME VARIABILITY
L. Goodmae and K. A. Karp
Acoustic scattering cross sections for redium
Inductions have been delived from the fundamental wave equation. The effect of a finite
scattering volume has been snalyzed. fluid
valoitly fluctuations can be shown to produce no
backacatter at scattering angle 8-1800, independent of the affections form of the velocity
field. Scattering from cound speed fluctuations
for the atmospheric and occanic cases is compared,
bying a cylindrically symmetic form about the
vartical direction for temperature fluctuations,
explicit expressions for the exattering cross
explicit expressions for the exattering cross
explicit expressions for the scattering siringth based on obtained values of
treations is siringth; based on obtained values of
treations is submitted to the scattering volume, scattering trengths are of
other frequencies provided the median variability
spectrum is technic.

13 18

The Great Solar Eruption of May 24,

Neil R. Sheeley, Jr., D. J. Michels, R. A. Howard, and M. J. Koomen

E.O. Hulburt Center for Space Research Neval Research Laboratory Washington, D.C.

The sequence of imeges on today's cover of Eos shows he most speciacular solar maes ejection observed to dele with the Nevst Research Leboratory's Eerth-orbiting coronegraph. Preceded by a loop-shaped coronal structure, en enormous eruptive prominence is visible both expanding and moving outward across the coronagreph's 2.5-10.0-Re annular listd of view. As it left the field, the prominence dwarfed the sun itself, whose size end location are indicated by the smell white disk in the lower-right photograph.

The prominence can be recognized by its characteristic structurel detail and by the lact that its relativaly unpolarized radiation is not blocked by the polarization-analyzing rings thei are laintly visible at 5  $R_S$  and 8  $R_S$  against the coronal background. The H $\alpha$  8583-Å line of neutral hydrogen is the principal prominence emission line in the coronagraph's 4000-7000-A spectral bandpass. On the other hand, the strongly polarized coronal radiation is continuum emission originating at the occulied solar disk and Thomson scattered by coronal electrons in the 2.5-10.0-Re lield of view. Both the prominence and the expanding coronal 'top' have been enhanced in our cover photograph by subtracting a presvent image from each picture.

When such prominences are observed prior to their erupsen, they reveal a wealth of fine structure similar to thet shown here, but with a spatial scale that is more than en arder of magnitude smaller. This fine structure has made it dificult to determine the physical properties of even quiesceni prominences, despite numerous atlempts to do so over the years. The composition of a prominence is believed to be similar to that of the sun Itself: 90% hydrogen,



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Cover. This earlies of images shows the changes in the sun's cuter corone that are associated with a very large aruptive prominence, Surrounded by a bright coronel loop, the prominence expended in size by an order of magnitude as it inversed the cororegaph's 2.5-10-R s lield of view at approximately 700 km/s. The sometimes can be distinguished from the corone both by its characteristic form. adensic liner detail and by the lact that its intensity was not rediced by this polarization enelyzer ringe that are teintly visible splinst the corone at 5 Rs and 8 Rs. The 4000-7000-A bandpase shows the corone as strongly potarized Thomson-scaltered photospheric amission and the corone of the corone spheric amission and the prominence as relatively unpotentied  $H\alpha$  . SSS-A line emission. In the lower right image, the white area indicates the plant of the polar color. cales the size of the solar disk, and the scale is merked in soler radi. The Navel Research Laboretory white light coronegraph has been operating euccessfully on the DOD estellite P78-1 eince Maich 1979. (Nevat Research Laboratory photograph courtesy R.A. Howard Nevat Research Laboratory photograph courtesy.) R.A. Howard, M. J. Koomen, D. J. Michale, and N. R. Sheeley, Jr.)

9% helium, and trece emounts of oxygen, cerbon, nilrogen end the less abundent elements. The hydrogen is estimated to be from 50% to 90% lonized, end the resulting electrons heve dansities end temperatures of epproximately 10<sup>10</sup> cm<sup>-3</sup> and 10<sup>4</sup> K, respectively. In contrast, the fully ion-ized coronel plesma has an electron density on the order of 108 cm<sup>-3</sup> end e tempereture ot approximately 108 K near the eun's surface.

These estimates heve often raised the gusstion of how a reletively cool, danse prominence can persist in the hot corona for severel weeks to months prior to its eruption. The usual rasponse is that the prominence is wrepped somehow by a protactive magnetic tield which shields it from the hot and highly lonized corone. Indeed, observetions of the sun's eurisce megnetic tields and their associeted etmospheric tracere do point to the possible existence of meanelic lields twisted somehow eround or through prominences. Despite this supposed shielding, the individuel prominence structures seem to heve thermel skin depths within which the electron temperature drops from 106 K to 104 K. This idee is supported by the lect linet e prominence looks remerkebly unchanged when observed in emission lines that are formed over a wide renge of lemperatures from approximately 104 K to 0.5 × 108 K. Evidently Ihs lerge-scale eppearance of the prominence is reletively insansitive to whether the radiction is from the 'outer skins' or

'inner depths' of the unresolved prominence line structuras. It one uses the sequence of images to trace the outward motion of the Mey 24 eruptive prominence, he linds a radial velocity (in the plane of the sky) that quickly eccelerates from 350 km/s at 2.7  $R_{\rm S}$  to e neerly constent value of 700 km/a between 3  $R_{\rm S}$  and 10  $R_{\rm S}$ . Thus, in this sequence, the prominence motion rapidly exceeded the sun's escape velodly, which is 818 km/s at the surface and fells as the square rool of the radiel dialanca (376 km/s el 2.7 Rs end 195 km/s et 10 R<sub>S</sub>. Furthermore, this prominance molion wes highly supersonic, compared to the 170 km/s proton thermal speed of the 108 K coronel plasme. This fact raises the presently unresolved question of whether the preceding coronal 'loop' should be interpreted as an outwerd-propegating ahock wave, en expansion of overlying magnetic Ilux loops, or both.

Perhaps the most noteble espect of the Mey 24 eruption is the lact that the prominence meinteined its overall shape while increesing its lineer dimensions by an order of megnitude. Except for the large scale difference, the structure looked just as much like e prominence at 5-10 Rs in these relatively low-resolution (1.25 arc min) coronet images as il did at 1 Re in much higher resolution (2 arc sec) groundbesed Ha imeges obtained prior to the eruption. Evidently, this shape preservation reliects a systematic large-scale motion such as would be produced by a mass-llux-conserving 'explosion' or by a magnetic expension. In comparison, e diffusive expension caused by thermal motions or by rendom motions of the prominence's initial line structures would have blurred out the prominence's shape in en expansion of this magnitude. Moreover, the 17 km:s proton thermal speed of e 104 K prominence is much too slow to have produced the observed 100 km/s widening end 400 km/a lengthsning of the prominence.

As in meny other sruplive prominence events, no essocialed soler liere or large X ray burst was observed from Earth, despite the evallebility of sultable observations. Howevar, all the time of its eruption the prominence was located 2 days behind the sun's east limb, where en essociated liare or X ray burst might well have been hidden. Indasd. when solsr rotation cerried this longitude around the sest limb into view, one could see that a large new magnatic region had emerged near tha former prominence's previously gulet location. One would expect this tlux amergance to heve dialurbed the prominence, regardless of whether it may also heve produced a solar tisre.

Finally, we mention that this Neval Research Laboratory coronagreph opereled routinsly on the Department of Defense Space Tesi Program Saisille P78-1 during 1979 and 1980, end continues to do so in 1981. As we process these date and compare them with other observations during this ara of high sunspot activity, we hope to understand these aruptions and their influence on the interplanetary medium.

#### Acknowledgements

The NRL coronegraph was leunched on the P78-1 spececraft under the suspices of the De grem. Wa ere greleful to STP, NASA, and the Office of Nevel Research for their support in this endeavor. We are also grateful to D. Roberts, F. Herlow, R. Chalmson, and R. Sael, who provided enginearing end technical support, end to T. Rohits and W. Funk, who have assisted with the data reduction. In the preparation of this arlicts we have benefited from conversellone with severel of our scientific colleagues, both at NRL and elsewhere.

The four authors of this stricte ere research physicists et the E. O. Hulburt Center for Space Resserch of the Neval Research Lab oretory, N. R. Sheeley, Jr., received his education of the Collionnia institute of Technology. His current interests are in the elructure and evolution of solar magnetic tields and their extension into inter-planetary space. D. J. Michels, principal investigator of the corona-graph experiment, was educated at St. Pater's College, Fordham University, and the Catholic University of America. He is interested In the solar corona as a source of the soler wind and a driver of geomegnetic enomellee: R. A. Howard was educated at the University of Maryland. He is responsible for the data system and the eutomated observing program that produced the coronal images accompanying the article. His research interests center on the dynemics of coronal structures and their extension into the soler wind. M. J. Koomen designed the first spaceborne colonagraph tor flight in an Aerobee rocket in 1963, From Ihal experiment grew e series of successful designe for rocket-borne and orbiting coronsgraphe (including the present instrument), which produced the liral syldence that showed repid evolution of coronal structures and that first optical observetions of coronel mass ejections. Educated at the University of Rochester, his research interests include the outer solar corone, precision rediomatry, and space optics.

## News

#### Rough Seas for Ocean Drilling

Federal lunding for the Ocean Mergin Drilling Program (OMD) mey be in jeopardy in Congress. The original budget request by the Carter administration for liscel year 1982 was \$16 million (Eos, Mer. 24, 1981). The Reegen administration Office of Management and Budgat recommanded raduction to a level of \$12 million, but now the program could be scrubbed altogether. Recent action teken by the House Subcommittee on Science, Research, and Technology has included cutting the OMD program from the Netionel Scisncs Foundation FY 1982 budget. This action is sponsored by e Democratic House mejority.

Representative A. Ertel (D., Penn.) raised strong objections to the progrem's being supported jointly by the federal government end Industry, in this case petroleum companies. In an ellort to get the program underway lest yeer, 10 oil companies were asked to support the program financially and technically. The tederal government was to pay for only hall the costs. Ertel interpreted the joint effort as 'a subsidy of the oil compentes," and 'not a science project." He has stated to the effect that the DMD program was one ol petroleum exploration.

Actually, the OMD progrem was creeted as a acientitic drilling program to explore the geology of the continental slope. There la tundamental science to be gained on the cruciel boundary between oceenic and continental plates. True, the oil companies would like to tind oil on the slopes-so would many other interests. But, presantly there is precious illile scientific data available on the ocaan mergins. The oil companies will need en extensive basa before axploration can ever begin. The rules agreed upon are that drilling is not to be 'on structure,' i.e., drilling is not to be locatad on petrolaum or ges locetiona. The locations ara to be scientifically located.

Technological edvances for the OMD progrem ara to be manitold. Drilling at depths in excess of 4000 km of water has not been done before, much less with the required blowout protection and risar mechanism. Davalopment of those techniques will take some years. The spinoil should be of value to industry, government, end research interests.

The last word on the OMD program in the House of Representatives is not yet 'cast in concrete,' The NSF budget ewalts tull committee approval and appropriations. Officer portions of the budget that had been reduced sharply by OM8 have now been increesed by House Oemocrats, while the Ocean Margin Drilling Program was being cut The outlook for the program does not look bright. Further, passage of the NSF budgel through the Republican-dominated Senate may be difficult as well. The mood to cut the program may dominate it support is not established —PMB

#### Little Solar Impact From Planets' Alignment

Contrary to some projections, plenetary elignmants of the type that have begun recently (when the sun, Venus, Eerth, Jupiler, and Seturn move into almost perfect alignment) should have no percapible effect on solar flare activity. Some researchera have postulated that the increased gravitational attraction exerted on the sun by the aligned plensts could produce masaive eruptions near sunspots. The rediction and particles directed earthward by the sun, eccording to this hypothesia, would change the atmosphere in e way that would slow the eerth's rotation; and this change in rotation rate would ceusa the large plates which constilute the earth's cruet to grind together more vigorously end cause major earthquekes. Because Jupiter is the largest of the planets, and an exerts the most gravitational eliraction, Ihla geophysical domino theory la somatimes referred to as the Jupitar Effect. But, ei teaet ai the aclar end of this theory, one would not expect much change in solar ectivity from planetary alignments of this type.

'We may have major eolar tlares occuring at about the same time as this planetery alignment, explains Patrick McIntosh, of the Space Environment Laboratory in Boulder, Colo., 'but they should have little or nothing to do with the lect that the planets are aligned.' This is not to say that such alignments produce no perceptible effect, he notes. but that the effect is a very email one. There is some eviinfluence on sunspot number. But this apparent connection seems to pertain only to variations in sunspot number, not to the magnitude of solar activity. Certainly, planetary alignment should not be considered a primary mechanism behind solar flares."

The term, sunspot number, is an index developed ebout a century ago that counts all sunspote, then adds 10 times the number of aunapoi groups—thus if there were a single sunepot on the eun, the aunspot number would be 1 plus 10 times 1, or 11. We find that sunspot number dose not correlate well with the incidence of powerful liares," Mcintosh says, 'For example, we've had a rather high eunspot count for this precent 11-year cycle of sunspot epityliy, but we've had relatively lew lerge flares. The epois we've agen most ere relatively smell, relatively stable ones. Flare activily layors the larger, more complex sunspols. The most powerful flarea in the last sofer cycle did not occur when we were at our peak sunspol number.' McIntosh acknowledges that the planets do produce lidee on the eun by the sweep of their gravitational fields but notes that the effect is quile amait. 'Solar ildea caused by the planets' gravitation ettraction are measured in millimajars," he saya, 'compared to the rether large tidea caused by the moon and aun in our ocean and stmosphere, in fact, most solar astronomers. would say the aun barely knowe the plenets are out there."

(News cont. on page 154)

The planetary alignment that began March 25 end evolved through April 7 placed Selurn, Jupiter, Earth, The sun, Venue, end Mars In a rough line, a contiguretion properly called 'eyzygy.' Aboul a yeer leter, thay will come into a much rougher conjunction on the earne side of the sun. But, eccording to McIniosh, thie month's ayzygy pieces the planete much closer to a common tine, end would be the most fevorable configuration for the eo-celled Jupiler Effect to be lell.—PMB 55

#### **Voyager Status Report**

As the Voyegar 1 epacecreft apeeds away from Salurn, II leavea in its weke a pleihore of date for the team eclenists to puzzle over. Although they still grappia with dale from the November 12 encounter, the learn ectentists have put together e report of their early findings. This report, pubilshed in the April to iasue of Sciance, wee recently summerized el NASA heedquertars by representatives of the Vovager team

The enetyzed deta confirm some earlier hypotheses (Eos. Dec. 2, 1980, p. 1201) end necessitete reshaping of olhers. For exempla, the 'epokae' in the B ring ere probably explainable by Kepterien lawa, or ao it was hypothesized immediately after the Seluth flyby; magnetic forces elso mey be affecting the ring. But Titan wee found not to be the lergest eatellite in the aolar aystem.

Seturn'a rings, though complex, do not counter known laws of physics, explained Bredford Smith, Voyeger Imeging leam leader. The problem, however, is in applying the known lews. The apparent 'brelding' of atrende in the outermost F ring remeins a myalory, as doos the mechanism by which the myried rings and ningtels remein diacrole. The satsifite resonanco Theory proposed by Peler Goldreich at JPL end Scott Tremeine at Princeton University seems to hold true for meny of the known satellitee. However, the Cring'a regulerly spaced ringlets show no clear association with satellito resonances, Smith added.

Tilen's etmospheric haze previously prevented eccurate measuroment of the satellite's size. Edward C. Stone, Voyegor project scienitat, reports that Tilan's rediue is 2570 km, about the distence balwoen Dellas end Boston. The lamperaturo el Titan's surfaco is 93° K; lhe pressure is 1.8 etmospheres. Stone said. Melhene's Iriple poini-the temperature at which it cen oxist as a solid, tiquid, end gea-is 91° K. Therefore, if the etmoaphere conteined 5% methane, Stone explained, e methane ice cloud would form 5-10 km above Titan's surfaco. The omount of methens in Titan's etmosphere is uncertoin, however.

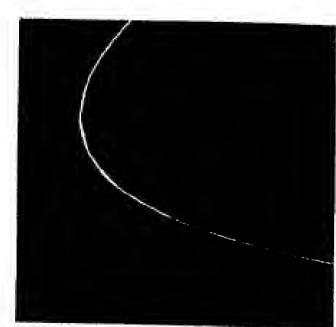
Smith reported thei the berely visible brightness difference between Titan's northern end southern hemispheres may be rolated to the effects of the solstice. Than shows a phase lag of 90°, or one quarter of a yeer, Smith explained. Therefore, at the equinox the effects of the solstice would be visible. Tilan is just entering equinox now.

Heavy cratering on meny of Seturn's safellites may be

## Status of Voyager Spececraft, April 1, 1881

	Voyager 1	Voyager 2		
Spacecreft distence from Earth, km	1,381,718,789	1,145,473,428		
Spacecreft distance to Saturn, km		138,129,314		
Opacecraft distance traveled since teunch, km	2,430,281,184	2,088,807,280		
Spacecraft velocity reletive to Earth, km/a	20.8	22.3		
Spacecraft velocity relative to sun, km/s	21.2	18.0		
Date of Saturn encounter (closest epproach)	Nov. 12, 1980	Aug. 26, 1881		

Source: NASA



Three visible braiding 'strands,' composing Seturn's Fring, are seen in this photo taken on November 12, 1880. The Fring Is bounded by two shepherding attellites discovered by Voyager 1. Scientists believe the gravitational effects of the two satellites may confine particles in tha F ring to a narrow band. In addition, the braiding structure of the ring may be e result of the eccentric mo-tion of the two small satellites. That A ring and the Encke Division are seen to the upper right. (Photo courtesy of NASA).



Spokelike leetures in Seturn's rings are seen as bright areas in this image taken by Voyager 1 on November 13, 1880, when the epacecraft was 936,000 km from the planet's cloud tops. Where sunlight forward-acetters on the rings, the apokes appear bright the seme leatures appear derk in backecattered light. In this view, the concentric structure in the B rtng increases contrast and accept eles hundrede of light and dark ringtets. (Photo courtesy of NASA).

the result of Iwo bomberdment periods, the scientists believe. Moet of the large craters (20 to 100 km) were formed during the first period, according to the hypothesis. Smoothing of the surfeces of the lerger satellities were accomplianed with lectonic sciivity, perheps driven by radio-nuclides. The second bombardment pariod produced smeller cratere. Material spewed into the Seturnien system during the first bombardment may have been responsible for the second 'bombing.' One problem with this model, Smith said, is that scientiste ere uneure what the driving lorce was thet amouthed Tethys' surface, eince the satellite is el-

most entirely ice. Another problem is explaining the unblemished complexion of Enceledes.

Soon Voyeger 1's elster creft, Voyeger 2, will take the epotlight. Scheduled for its Saturn encounter on August & Voyager 2 will ettempt to fill in geps of information left by Voyeger 1. Specifically, the creft will take e closer look at Enceladas, the eatellite Hyperion, end the complexing system. JPL's Devis expects the programing of the experment sequence to be completed by late May or early June. He gave both creft e cleen bill of heelth: Things era going according to plan.'—BTR &

### **HASA Energy Study Unveiled**

Meeting the energy needs of the world in 2030, when the projected population will be 8 billion, can be done, but not without international cooperation, e mix of energy technologles, end an understending of the dependence of resources and use. That'e the optimietic conclusion of the 7year global energy etudy by the international institute for Applied Systems Analysis (IIASA).

Results of the international study were published last month in two volumes. Energy in e Finita World: Paths to a Suetainable Future outlines the stretegies IIASA believee will meet energy needs; its compenion volume Energy in e Finita World: A Global Systams Anelysis presents the

sludy's complete technical findings. According to Wolt Hatels, leader of the Energy Systems Program Group, IIASA's conclusions ere elmilar to those re eched by the 4-year study done by the National Academy ot Sciences' Committee on Nuclear and Alternative Energy Systeme (CONAES) (Eos, Feb. 19, 1980, p.90). However, the results differ in the types of trensition periods to technology mixee. While CONAES envielone one trensition period (1985-2010), IIASA sees two. The first will lest through 2030, and the second trensition will occur through the end of the 21st century.

Globel Primary Energy by Source, Two Supply Scenerios, 1875-2030 (TWyr/yr)

	Base Year 1975	High Scenario		Low Scenario	
Primary Source		2000	2030	2000	2030
Oil Gee Coal Light weter reector Fest breeder reector Hydroelectricity Solarc Otherd	3.83 1.51 2.28 0.12 0 0.50 0	5.88 3.11 4.94 1.70 0.04 0.83 0.10 0.22	8.83 5.87 11.88 3.21 4.88 1.48 0.49 0.81	4.75 2.53 3.92 1.27 0.02 0.83 0.09 0.17	5.02 3.47 6.45 1.89 3.28 1.48 0.30 0.52
-T-	8.21	18.84	35.65	13.59	22.38

\*Terrewell year per year; t TWyr/yr = 30 x 10<sup>18</sup> BTU bPrimary ludle production or primery ludls as inputs to conversion

or ratining processes—for exemple, coat used to make synthetto tiquid fuel is counted in coal figures. 'soti' soler-individual roottop collectors-and gleo smell emounts of centrelized solar electricity.

d'Other' Includes biogee, geothermal, and commercial wood use. \*Columns may not sum to totals because of rounding.

Source: Energy in a Finite World: Pathe to A Sustainable Future

During the first period, the globe will continue to consume fossil fuela, but the fuels will become incressingly dirty. The major transition to renewables—soler, geothermai, ocsan currents, wind power, hydropower, elc.—will come late in the next century, according to the IIASA re-

The study engaged the help of 140 scientists from 20 countries, a first for this type of sludy. IIASA stresses the global neture of the energy problem: 'While the problem trenscenda national borders, policy enalyses tend to follow suit only eelectively... But such provincialism can only lead to dangerously misguided national policies, the report stetes. Following this reesoning, IIASA included all countries in the analysis, but grouped them into eaven regions categorized by naturel energy resources and economic atructure. Geographic proximity was not necessarily a conatructure. Geographic proximity was not necessarily a con-sideretion. For example, one region encompasses Western Europs, Australia, Israel, Japan, New Zeelend, and South Africa. These have developed market economies, but are poorer in resources than other developed regions.

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The initiel, 50-yeer trensition was chosen for four reaeons that ellow for technological and social change. First, by the year 2030, IIASA estimates that the world population will double from its prasent 4 billion—the eleepesi incess ever. Second, 50 yeers is epproximately two complete life cycles for power plants and energy tacilities. Third, the line period represents two human generations and the accompanying sociel changes. Last, the time frame allows for merket penetretion of edvenced energy technologies. To expect e trenellion to a eustaineble worldwide energy system within anything much less than 50 years would be to flegrently ignore history, according to fIASA.

increasingly dirty fossil fuels will be used through the feet trensition period, the IIASA report seid. Global dependence on synthetic fuele end unconventional oils will increase through 2030. Approximetely 80% of the energy suppliedr 2030 will be from dirty fossil luels, Hälsle said There is m wey of partly escaping the dirty route, he edded. The # port states that aometime eround 2000, large-scale coalquefection will become necessery, elthough Halee could not define the proceee most likely to be used. Joining liquit faction in 2000 will be fest-breeder reectors, in IIASA's po-

## Two Benchmerk Scenarios

IIASA developed two benchmark scenarios based on the level of worldwide energy demand-high and low. As 1luetrated in the accompanying teble, the high ecenario relles mostly on coal-fueled energy in 2030, while the kw scenario rallee almost equelly on oil ea on coal. Magneto hydrodynemics and fusion energy will not eignificantly contribute to global energy by 2030.

Three allemative cases also were presented: s nuclear moratorium case, en enhanced nuclear case, and zero? capita growth rale. In tha lest, globel energy use is restrict ed to the present rete and requiree extreme concervation

Given the world eltuation and the history of noncooper tion among nationa, le the optimism expressed in the repu justified? Although Häfele aald he egrees with the bottom line of the report—that energy needs can be mel with work resources he is less optimistic about the needs being met. He pointed to an increasing dicholomy between the eption of reelity and reality itself. The political economics, and the cold war could block the securing of energy to meet global demande.—BTR &

Geophysical Managraph 16 Flow and Fracture of Rocks (\*\*\*

> edited by H.C. Heard, I.Y. Borg. N.L. Carter and C.B. Raieigh

Oadloated to Professor David T. Griggs whose plane esearch into the field of rock deformation has proved to be most volucidis. Among the many studies included in this volume are the

experimental loiding of rocks under confining pressure, the particity at single crystale of synthetic quartz, the deformation processes in the processes in the upper manife and para pressure in Geophysic • 352 pages • Order No. GM 1600. • Lut Price \$18.00 Orders under \$30.00 must be prepold

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Petrofeum Data Available

New geological and geophysical data associated with ceriain regione in the Netional Petroleum Reserve in Alasks (NPRA) are avellable to the public from the National Geophysical and Solar-Terrestrial Dete Center.

These data were collected and processed by several companies under contract to the U.S. Geological Survey. Purpose of the data collection was to evaluate the peiroleum potential of portions of the NPRA.

included in the available date are selemic date, well logs, end gravity data through September 30, 1980.

Inquiries on the filers listed below should be addressed to National Geophysical and Solar-Terrestrial Data Canter, NOAA/EDIS (D82), 325 Broadway, Boulder, CO 80303 lelephone: 303/497-8826).

1981 (SE-E) NPRA 10 Well Loge and Auxillery Data (1978-1880) 1981 (SE-D) NPRA Seismic Oele (FY 1980) 1981 (SE-D) NPRA Setantic Octo (FT 1980) 1980 (SE-NN) NPRA Gravity Dale (1974–1880) 1980 (SE-MM)NPRA Geological Octo (FY 1978) 1980 (SE-LL) NPRA Selemic Dela (FY 1878) 1980 (SE-HH) NPRA Common Depth Point (CDP) Field Tepes 38

#### NRC Associateship Survey

The National Research Council (NRC) wants to locate ita lormer research associates and visiting scientists research associates to verify officiet records. The NRC also hopes to essess the effects of the reseerch aasociateship programe on career development.

All associatee should send their correct mailing address, dales of tenure, end the name of the laboratory where the essociateship was pursued to F. A. Crump, Assistant to the Director of Associeteships, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418. S

#### Geophyaicista

John S. Dickey, Jr., has been appointed chairman of the geology department and Jeesle Page Heroy Proteesor ot Geology at Syrecuee University. He will leave his post as director of the petrology/geochemistry program in the Division of Eerth Sciences et the National Sciance Foundation to begin his duties at the university on July t

# **New Publications**

China Science and Technology

international Science and Technology Information Service, Hong Kong, \$5.00 per leeue.

Reviewed by Cerl Kleslinger

The obvious purpose of a review of a new abstract journel is to bring it to the ettention of potential usera and offer some idea of the ecops of the contents. I was een! Volume Number 2, October 1980, and, if it is typical, the publication will be of definite value to many readers of Eos. The stated purpose of the journel le to give them (i.e., eclentisie outside of Chine who cannot read the Chinese lenguaga) an outline of the latest development of eclence end technology in China.' From the eemple I exemined, the journal schieves this purpose admirebly. Sixty-nine highly reputed Chinese periodicels' provided the material for the particular leeue. The claim that each leaue will contain about 500 abstrects eeems exaggerated, eince many of the entries are titles only. However, even these serve to give a feeling for the mein lines of current research interests, and many of the reel abetracts are sufficiently long end detailed to be useful as sources on research results (though without the supporting data).

The abstracts are classified under major disciplinary heedings, with appropriate subheadings; methematics, eetronomy, physics, chemietry, earth science, engineering physics, mechanical engineering, electrical and electronic engineering, architecture and civil engineering, transportetion engineering, technology of industrial chemicals, and other brenches of engineering. The classification of the pepers under these headings is tairly arbitrary. Meterial of Interest to verious sections of AGU is acattered inroughout, but most relevant materiel is naturally found under astronomy, physics, and earth science (an entry on acupuncture signale in cerebrel cortex under "astronomy" is a rather stertling slip). The earth eclence section is turther divided by topics ranging from geodesy and geophysics, through geodynamics (Internal and externel), to oceanography, hydrogrephy, metaorology, petrology end gaochemistry, and

economic gaology.

Chine Science and Technology Abstrects is eapecially attrective es en information source baceuea tha publishar olfers copies of the original erticles (\$0.50 per page), English traneletions (\$10 per 100 English worde), and extended English ebstrecte (roughly one-tanth tha original langth, et \$15 per 100 English words). The quelly of the English fanguaga in the abstracts I read is quite good so that one can ba optimistic that the trensletions offered will be estimately with regerd to readability.

Cerl Kissingar is with the Cooperative Institute for Rasearch in Environmental Sciencas, University of Colorado at Boulder, Bouldar, Coloredo.

### **New Listings**

Items listed in New Publications can be ordered directly from the publisher; they ere not evaluable through AGU.

Advenced Chemical Mathods for Soll and Clay Minerals Research, J. W. Stucki, W. L. Banwert (Eds.), D. Retdel, Hinghem, Mass., vill + 477 pp., 1980, \$58.00.

Archean Greenstona Belis, Developments in Precambrien Geology 3, K. C. Condle, Elsevier, New York, 434 pp., 1981, \$122.00.

A Climatologic end Oceanogrephic Analysis of the Georges Benk Region of the Outer Continentel Shelf, Final Report to the Bureau of Land Menagement, U.S. Department of the Interior, U.S. Depertment of Commerce, NOAA, x +

The Primordial Bond: Exploring Connections Between Men and Nature Through the Humenities end Sciences, S. H. Schnelder and L. Morton, Plenum, New York, xit + 324 pp., 198t, \$15.95.

United States Eerthquakes, 1978, C. W. Slover and C. A. von Heke (Eds.), U.S. Department of the Interior end U.S. Depertment of Commerce, Boulder, Colo. vit + tt2

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Plenetery Geo o associate professor position starting September 1, 1981, or as soon as possible thereafter to teach and conduct research in planetary geologic pro-cesses on Earth and other planeta. Research should be on understanding the physical processes for example important and physical processes for example, impact cratering, volcanism, tecto-num) responsible for like origin of planetary eur-laces. Applicants must have Ph. D. In planetology seconds of contract of the contractions Rophysics or geology. Deadline for applications is line 15, 1981. Inquiries to: Paul C. Hess, Chairan Department of Geological Sciences, Brown inversity, Providence, RI 02012. An equal opportunity and affirmative action em-

Faculty Opening. The Ospariment of Geological Sciences of the Stete University of New York at Abeny invites applications for a tenure track faculty petion which will be aveileble from September 1, 1981 at the sealested professor level by a consent? 1981 at the assistant professor level for a research charled scientist to join a department with scendist to join a department with stengths in strictural geology, tectonics, geochemisty and petrology. Applications are invited from the petrology. Applications are invited from the properties of the petrology of the petrology. Applications are invited from the petrology of t "gment studies in these fields. Selery will be neklinble. Letters should be addressed to: Prolessor
klain Burke, Cheirmen, Department of Geological
Scences, co Personnel Oepartment, State Universty of New York at Albany, Abarry, N.Y., 12222."
Stary at Albany is en equel opportunity/effirmaforties and handicapped are especially welcome. Two Winter-over Positions in Antarotica. Two positions are available to conduct scient Illic measurements in Antarctice of the earth's high strnosphere. These persons will winter-over at Siple and South Pole stations in 1682.

One position will be as engineer sciential at Siple Station, Antarctica. The primary responsibilities of of a High Frequency (100 kHz to 30 MHz) varical incidence rader system and a sophisticated optical experiment conducted by the Lockheed Pelo Alto Research Laboratory. The rader system to a 10 kg tonospheric sounder using the letest techniques of RF and digital electronics; real-time control of the transmitter and receiver and initial date processing are hendled by two micro-computers which are in turn controlled by a diek-based minicomputer sys-tam. Minimum requirements for this position era e 6.S., practical experience in digital and analog alectronics, and experience with computer soli-

The second position wilt be as a field engineer at the South Pola Station, Anterctica. The applicant will be responsible for the operation and maintenance of a variety of uppar atmospheric research experimente. The experimental apparatue includes riometers, photometers, an tonosonde, magnetometers and an all-sky camers. Minimum requirements are a 6.8, or aquivalent practical electronics

The period of amployment is expected to run from late summer 1981 to February 1683 (with a possibility of extension depending on available funding); both positions require that the applicant be resident at the South Pole or Siple during the Antercito winter. Successful applicants will undergo periode of training at Utah State University. Lock-haed Research Laboratory, and the University of

Applicants should submit a resume and request three letters of reference be sent by 15 May 1981 to F. T. Berkey and J. R. Doupnik, Center for Almo-apheric and Space Sciences, Utah State University, UMC 34, Logan, Utah 84322, Telaphone (801) USU is an equal opportunity employer M/F.

Structural Gaologist. The Department of Geophysical Sciences invites applicants for a len-ure track structural geology position at the assistant or associate protessor tavel, beginning August 1981. Ph.O. required. Salary commensurate with

Osparimental equipment includes a digitizer, various geophysics equipment, end a remote sensing laboratory with an edgewise enhancer. The candidate will have the opportunity to substantially add to his or her equipment needs. Present computer that sensitive will be sensed. lities include a OEC 10 and IBM 360-44, while PK 3240 system with 16 megabyte capacity is un-

der development.

OOU is a state-supported university serving nearly 15,000 atudenta end is situaled within the seventry Hampton Roads metropolitan area that is nettonally known for its historic, racreational, and cul-

Send vitae, a brief discussion of research interest, and arrange to have three latters of reference by May 1, 1981 to Or. Oemils A. Darby, Chairman, Department of Geophysical Sciences, Old Domin-ion University, Noriolk, VA 23508. An affirmativa action/equal opportunity employer.

### Rijksuniversiielt Utrecht

The subfaculty of Geology and Geophysics at the State University of Ufrecht (the Netherlands) invites epplicants for the position of

## **LECTURER** (wetenschappelijk (hoofd) medewerker) M/F,

In the workgroup Exploretion Geophysics, which is e part of the Department of Geophysics of the Solid Earth.

Cendidetes should have experience for et leest four years, shown by euccessful surveys or publications in at leest one of the following fields:

1. electric (including electromagnetic) prospecting,

2. telluric or magnetotelluric investigetions,

3. interpretetion of electric end nucleer well logs, end

4. prospecting by the self potentiel end the induced polarzetion method.

The duties include teeching (in English or Dutch) of courses In electric prospecting methods and the supervision of prectice end fieldwork. The lecturer is expected to conduct reseerch in a fleid related to his experience, by preference in the fleid of physical and pelrophysical foundations of well log Interpretation or on the application of magnetotelluric methods to exploration problems.

It concerns a temporary eppointment for four years with posability for tenure efter that period.

Selery, depending on age and experience to a maximum of

Cendidetee ere requested to submit their application, including e curriculum vitae end e liet of publications within three weeke efter publicetion to

Personnel Depertment Institute of Earth Science Utrecht Budepestlean 4 3508 TA Utrecht The Netherlands, hr. 145.001.

## Director **CIMAS UNIVERSITY OF MIAMI**

The University of Minmit is searching for a director of its Cooperative Institute for Marino and Atmosphoric Studios. CIMAS was established in 1977 by the University of Miramt and the Environmental Rosearch Laborntories of the National Oceanic and Almospheric Administration to serve as a local point for comprehensive research on apocific problems of the ocean and elmosphere.

Prosent research is concentrated in three areas

. Oceanic veriability on climatic scales

3. Ecological Modelling

The director should have a national and international scientific reputation in one of these three research areas and take an active interest in each of them. The euccossful candidata will olso raceive an appointment ea professor in one of the scientific divisions of the Rosenettel School of Marine and Atmospheric Science

of the University of Miami

The term of the director of CIMAS shall normally be live yeers and is renewable. Applications including o current prolassionel resums and threa references, and furthor information should be sont to Dr. Wenen J. Wieby, Chairmen of the Search Committee for Director of CIMAS, University of Miami, Rosenstiel School of Marine and Atmospheric Scienca, 4600 Rickenbacker Causeway, Miemi, Florida 33149. Nominatione and opplications desired by June 15, 1981. Position will remain open

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Structure: Cealogy/University of Illinois et Champelgn-Urbane. The Geology Deportments seeking a structural geologist for a tenure-track lessistant protessor) faculty position. A Ptr O. is required Gelary open. The auccessful centificite will be expected to teach advanced undergraduate and graduato courses in etructural geology and estabgraduato coursos il etrictural geology and estab-irsh a research program. For equal consideration, applications, including the names of firee refer-ences, should be sent by August 1, 1901 to Dr. O. E. Arderson, Department of Geology, University of Unions, 245 Notural Francy Buriding, 1301 West Orean Street, Urbana, IL, Offict. (217) 333-6713 Position to be fulled by 1, 1, 82 Position to be filled by 1-1-82

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Associate Prolesser. New Mexico Stats University. Geophysics at NMSU is an interdisciplinary progrems between the Department of Physemphasis in exploration geophysics. We are seek ing an additional fenure trock faculty member with a background in oither seismich and seismology or electrical and electromagnetic methods. The successful candidate will be expected to teach upper division and graduate courses, conduct research and its supervise graduate students' linesis and dis sertation research in the candidate's siea of expe has The appointes will also be expected to teach reshman end sophomore tevel courses in oither

physics or geology

N° nimum qual-lications include an earned declarete in geophysica or e closely related area and demonstrated research capabilities. Tauching oupe rience and a proven ability to secure research fund ing are desirable but not essential.

The expected salary range for this position is \$26,000 -\$28,000 for the mine-month ecademic

Applications and letters from at least three relaences should be submitted by May 15, 1991 to ei-Earth Sciences, Box 3AB or Dr. August Miller, Head, Oepartment of Physics, Box 30, Las Cruces,

New Mexico Stato University is an effirmative ec-

Professor Chomicet Oceanography. The Department of Oceanography of Taxas A&M University invites applications for an academic faculty position. The appointment is expected to be made at the levat of profess

Hence, applications are solicited from individuals who have demonstrated scholership in research and teaching Outstanding applicants suitable for appointment to academic ranks other then profesgiven to applicants suitable for appointment to the

To apply, or for further information, please contact Piofessor R O Reid, Head, Department of Oceanography, College Station, TX 77843 †713:

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Teolonophysics. Seek half-time visiting prolessor for the ecademic yeer 1981-82 to teach course in regional tectonics and seminar of awa ntment is tor helt-time for entire ec adomic year or full time for either tall or apring as-mester. Ph O. required. Rank and selery negotieblo. Inquirtos to: Paul C. Hess, Cheirman, Departmont of Geological Sciences, Brown University, Providence, Ni 02912. Oeadline for applications le

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Professor'Oceanography. The Capariment of Oceanography of Texas A&M University Invites applications for an academic feculty position. The ed pointment is expected to be made at the level of ed et la sections of the major sections of the Department—biological oceanography, chamical oceanography, geological and geophysical ocean-

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Exploration Osophysicist/University of Oktehome. The School of Geology and Geophysics at the University of Oklehoma will hire an expe Feoulty Position in Oceanography/Geolegy University of Northern Colorado. The Ospartment of Earth Sciences invites applications nenced explaration geophysicist to fill the Frank and Betty Schultz Professorahip, and le seeking nominationa and applications for the position. The person must be a distinguished scientlet who hee made important contributions to exploration geophysics through research. Preference will be given by a contribute the extraction of the professoration of for a full-time, tenure track faculty position in oceanography, elarting September 1681. We are seaking e person with e broad background in phy end one or mere of the related earth to e scientist whose specialty is seramic properties of earth meterials and who has gerned the Ph.O. science fields such as marine geology and/or sed-imantelogy. Major responsibility with be teaching be-ginning and edvanced courses in oceanography. The Schultz Protessor will provide teedership and guidance in establishing e quelity teaching and recourses in the releted field, end general education courses. A modest emount of research is possible and is encouraged. Applicants should precede the and is encouraged. search expleretion geophysics group. The University at Oklahoms has recently made a strong conmilment to the earth sciences with the esti Ph.O. degree or be in the final steges of completion ment of a College of Geosciences, to be housed in a new building. The School of Oeology and Oeo-physics will expand from its present faculty of 18 to of thet degree. Starting renk end salery will depend on experience end other qualifications of the candi-26 feculty members by 1986. This will include three

Applicants should submit a resume and at least scentists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources. three letters of recommendation to Dr. L. Gien Cobb, Chairman, Department of Earth Sciences, reity of Nerthern Colorado, Orealey, CO Applications are due April 30, 1981. Inquiries, ominetoris, and applications should be sent to The deedline for application is May 10.

John Wickham, Director, School of Geology end Geophysics, University of Oklahoma, Norman, OK The Unrversity of Oklahoma is en equel opportu-

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to L. D. McGinnis, Chairmen, Department of Geology, Northern Illinois University, DeKalb, it. 80115. An equal opportunity/effirmative ection employer.

si, and addresses of three references

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nineratogy, general geology, and perhaps optical sineratogy. The successful candidate will be re-

er yeer; someone who enjoys teaching is needed.

Persons on leave are encouraged to apply. Oead-line for applications is April 17, 1981. Please send

reaume to Cavid Krinsley, Cepartment of Geology, Arizona Stete University, Tempe, AZ 85281.

Petrology/Ocochomistry, University of New Grunswick. The Department of Geology has a tenure track position available from t Juty.

1981, el esaletant professor or higher level. The succeedul applicant will be expected to teach both

undergraduetes end graduates ea well es carrying out research and supervising graduate studante.

The epplicant should have a background in pe-

to teach in some aspects of petrology and geo-chemistry. The succeedul applicant will be respon

rochemistry and petrology and should be prepered

elble for eupervision of analytical fecilities including

Applicants should have e Ph.O. end preferebly,

post doctorel experience. Applications including a curriculum vitae and names of three referees

ment of Oeology, University of New Srunswick, Fredericion, N.8. ESS 5A3,

Texas Tech University: Feculty Positions. The Department of Geosciences is seeking

opplications for additional faculty members in gool-

ogy, geophysics and geochemistry; epplicante from all fields of geology other than paleontalogy will be

These are tenure track positions at the assistant professor level with appointments sterling September t, 1981.

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plans for research in their fields of specialization.

Applicants for the positions should submit re-

sumee, the names of et laest three persons from

whom the department may request letters of rec-emmendetion, and brief description of research in-

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Requires to develop global almosphere.
dynamics problem in the thermosphere. These positions are in support of science and epoli-cation tasks of NABA/Goddard Space Flight Cen-ler, Oreenbelt, Maryland end require one to work

An extensive background in the numerical simulation of physical problems by use of mini and large computers is required. Candidates must have M.S. or Ph.O. In almospheric sciences or physical sciences. Soth of these problems are required to the ences. Both of these positions are ranswable up to

geley range is \$21,000 to \$36,000 per enrum, depending on qualifications. Good Senelits, Qualited applicants should sand three relevences, selery history and requirements to: Dr. S. P. S. Anand

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Selemologist: University of Utah. The Unversity of Uteh le expending its geophysics program in the Department of Geology and Deophysics by adding a tenure Irack leculty member in setemology et the assistent to essociete prolessor tevel. App cants with backgrounds and epocielities in salan imaging end incorptical selamotogy will be giv-en preference. The individual will be expected to leech undergreduete and greduete courses, and in pursue en active research progrem with graduate

The department has modern teaching and reaearth programs in geology end geophysics, and has closs associations with the numerical analysis end data proceasing groups in computer science, electrical engineering, and methemalics. The geo physics component of the department has strong research and teaching programs in electrical and alactromagnetic matheds, thermel properties of the earth, potential fields, and selsmology. Current reseerch in selemology includes: earthquake re-search utilizing e new PDP 11/70 computer; me toring of the Intermountein selemic belt by e 55 station telsmetered network utilizing e new or PDP 11/34 computer; major experimente in selanic turs, and ellied research in tectonophysics of

The closing dete for epotications is May 1, 1981 and the appointment date is September 1981.

However, the search may be extended if e suitable candidate is not selected, in which case applicants of 8 openiors whether continues whether conti for e one-year visiting position for the scademic yeer 1981-82 will also be considered.

A Pn.O. is required for this position.

Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference. Quisited and names of five persons for reference. Quisited persons should send their applications to William P. Nash, Chairmen, Department of Geology and Geophysics, University of Utah, Satt Lake City, Utah. 84112.

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Purdue University. A tenure track appointment in the erea of surveying and mapping. Under graduate teaching in the areas of basic surveying adjustment computations, and introductory processing arminetry/photo interpretation; involvement in leaching graduate level courses, and in existing and new research programs.

Preferential consideration to candidates with a

Preferential consideration to candidate with a Ph.O. and land surveying registration (or in the Ph.O. and land surveying registration (or in the Propess of getting such degree and registration); rank and selary are ppen and depend on the experience and quelifications of the applicant. Send resumes, by 15 April 1981; to Head, School of Call Engineering, Purdus University, West Estayetts, IN 47907.

Rurdus is an actual apportunity/affirmative applicant. Rurdue is an a qual opportunity/affirmative action

Headr Serth Resourses Branch, NASA/ Anddard Space Flight Center. GS-1330-14/15: \$37,87t-\$50,112 per ennum, full-lime permanerii. The Earth Survey Applications Oivisien, Flight Center invites epplications for the epen on of Head, Earth Resourcse Grench. The umbent of this position is responsible for ptenning. managing, and conducting broad programs in e remete sensing beeld and epplied research and deta anelysis, empheeizing the development and demonstration of applications of remote sensing of earth resources from earth orbiting satellies. The primary areas of research in the Brench ere and use management, vegetation sciences includ-log agriculture/lorestry/rangeland and environment pring utilizing remotely sensed dete and ad-id rechnologies. Atso, significant effort is dedied to sensor data evaluetion in terms of applicallons and adenlitic utility, and to specification of a acquisition and intormetion extrection systems which best meet user actenuitic and resource manegement needs. An edvenced degree in earth or ical eciences is required with education in the ation edences, land use or environmentel mon

Indicating senior research eclentiat etetura Resumes/SF 171's ehould be sent to: Dr. Robert O. Price, Assistant Chief Earth Survey Applications Division Ooddard Space Flight Center

loring being specificalty preferred. Candidates

more responsible experience in the conduct, guid-

ca end management of remote sensing research

ems and clear evidence of e etrong research

chould also have severel years of progressiv

Greenbell, MD 20771 ne for applications is April 30, 198 t.

University of Hewai). The Hewaii Institute o cophysics and the Cepartment of Osology and cophysics of the University of Hewell Invite applicilion for tenure track positions evellable July 1, 1881. Applicants with specialties in any of the fol-

towing fields will be given consideration:

I. Marine geophysica with emphasis in mertne gravity and tectonics

2. Marine seismology

Merine magnetics
 Applicants should have a Ph.D. degree and a

demenstrated obility to conduct and promete ma-rine research. Ability to teach at all levels is re-quired. The position will be a joint one on an 11menth basis between the Hawali Institute of Geo-physics and the Oepertment of Oeology and Geophysics. The appointments will be at the rank ot sasistant protessor.

Apply with resume and names at three references to Charles E. Heieley, Oirector, Hewell tristitute at Ocophysics, University of Hewell, Henolulu, Hawali 96822. Closing dete la May 15, 1981. The University of Hawaii is an affirmative action and equal opportunity employer.

Chamical Coosnagraphy/Marina Osochomia try. Anticipated faculty opening at Florida State University, Applicants from ell specialites walcome—preference to candidetes who anhence ex sting programs in mains and atmospheric chemis iry sedimentery geochemistry end radiochemistry. Contact, Chairmen/Chemical Oceanography Search Committee, Oepartment of Oceanography, The Flerida State University, Tallahaseee, FL 52306. Telephone 904/644-6700.

Meteorology Studies Progrem Coordine-tor. The University of North Oekole anticipetes of fering an undergraduete degree in Meteorological Studies beginning the fall semester 1881. This pro gram will be very eppilicatione oriented, and will include coursee in dynamics, synoptica, reder meteorology, cloud physics meteorology, and forecasting among others. This co-sponsored program requires 40 hours for a major, plue twelve hours of calculus end twelve hours of physica, and will utilize to a great degree the research steff and facilities in the co-sponsoring departments of eviation and geogra-

The coordinator's position will include general overall edministrative responsibility for the program on a dey to dey basis, leaching of courses in synoptics, dynamics, and redar mateorology as well as being the primery student edvisor for the program.
Additionally, the position offers an excellent opportunity to be involved in research associated with the department of eviation's multi-year, multi-million dollar research contracts. Fecilities include e Citetion II jet cloud physics el rorsh, a Cheyenna turbo-prop research el roralt, a Stanik gilder, a 5 cm digitet weether rader, and a dedicated computer facility. The position is a 12 month non-tenured appointment within the department of eviction beginning to July 1981. The position requires a Ph.D. In meteorology and a strong background in teaching. A specialization in radar mateerology is preferred. Satary is commensurate with experience (\$25,000-\$35,000).

The Ospartment has experienced phonomonal growth in academics and research these post years, and ancourages applicante to send their resumes by 1 June 1981 to: Or. Patrick J Grady. Os partment of Avietion, Sex 8216—University Sietion Grend Ferks, NO 58202. The University of North Dakota offera en ettrective benefits peckaga, retire ment plen, and excellent working conditions

#### MARINE RESEARCH ASSOCIATE II.

Anelyzs and interpret vertical acoustic travel time and pressure dala. Prepare progrees and data reports. Assist in planning experimanta, instrument design modificalions, instrument preparetion, snd al-sss deployment and recovery operations. Dsvelop smpirical and dynamical models to be evaluated using EPOCS data. Ph.D. in physical ocsanogrephy plus experience in computer programming (applications) and FORTRAN, Submil resume by May 31, 1981 to Dr. Mark Wimbush, Wsikins Building, Bay Campus.

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Postdoctors/Research Associate Posttions, The Johns Hopkins University, Appiled Physics Leborstory. Positions are evellable for studies of magnerespheric lanespheric coupling, hydromagnetic waves, and pleama instabilities in the tenosphere and magnetosphere The estected candidates will panicipals in the analysia and interpretation of dete from epacecrati and greund-based redere es well as in the development and implementation of new ground besed and apocecreft studies. Positions ere for one year end are reneweble. Tenure mey begin et eny time through September 1, 1881. Applications should be addressed to Mr. Stevan F. Seyre, Oept. AOI-15. The Johna Hepkins University, Applied Physica Leboretery, Johna Hepkins Road, Laurel, MO

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#### MARINE RESEARCH SPECIALIST II.

Perform chemical research on orgenic pollutants in marine eamples. Collection, preparation, and chemical analysis of samples. Candidate must heve B.S. or M.S. degree end be familiar with gas chrometogrephic methods for the anelysis of synthetic organic compounds in samples of weter, sediment, and organisms. Knowlsdge of field sampling lechniques would be helpful. Submit resume by April 30, 1981 to Dr. James G. Quinn, Graduate School of Oceenography.

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# Meetings

## Pacific Energy and Minerals

A cell for papers has been Issued for the Third Circum-Pacilic Energy and Minaral Resources Conference, scheduled for August 22-28, 1982, In Honolulu, Hswaii, Theme of the conference is 'Assources for the '80's.'

in addition to the regular contistance assistons, preconfar ence workshops will be held on August 21-22. A preconlerence symposium on August 20 on Energy Research in the Circum-Pacific Ragion will be eponsored by the thiernstional Union of Geological Sciences. Geological Itald Irips and tours to other Hawallan Islands are stated for the weak alter the conlerance.

Abstracts for oral and poster papers should be received by January 1, 1982. Names of the eppropriets program chairman who should receive abstracts can be obtained by writing to Allen Mabra, Vics President for Exploration, ARCO International Oit and Gas Co., 515 South Flower Sitesi, AP-4985, Los Angelss, Cs 90071.

To receive complate conferance details, reservation forms, and Iravel information, contect the AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101 (telephone 918/584-2555). 38

## nternational Groundwater

A symposium entitied 'international Groundwater-The Promise and the Problems, I a scheduled for May 13 and 14 In New York City. Organized by the American Society of

## **AGU Midwest Meeting**

September 17–18 Minneapolis, Minnesota

Abstract Deadine: July 1 Convenor: V. Rama Murthy

Pspers and posters originating in or pertaining to the region are solicited for the following special ses-

Msnile structure and dynamics. Contact Geoffrey Osviss or Clem Chase. Rock water interactions: Hydrothermal processes

and metallogenesia Contact William Sayiried. Precambrien crustel evolution of the North American confinent. Contact Paul Welbien. Geomagnatism and pataomagnetism. Contact Su-

Hydrology in the mid-continental U.S. Contact H.O. Pisnnkuch or E.C. Alexandsr, Jr.

Uss slandsrd AGU format (sss pags 20 of Jsnuary 13 Eos) and sand original and two copies of ab-Bracts to AGU Midwest Meeting, 2000 Florida Avenue, N.W. Washington, D.C. 20009. Abstracts will be Published in Eos, with a substantive meeting report efter the meeting. There will be no abstract charge.

Civil Engineers' Groundwater Committee (part of the irrigaflon and Drainege Divigion), the sessions form part of the sociaty's International Convention and Exposition on May 11-15 of the New York Hillon Holel.

The program will consist of 12 papers and two panel discussions. International groundwater occurrence, development, and problems will be discussed by specialists from the United Nations and Food and Agriculture Organization, as well as from Australia, Egypf, Finland, India, Israsi, Pskistan, Saudi Arabis, Thailand, the United States, and

Weel Africa. For mors information, contact A. Ivan Johnson, Woodward-Clyds Consullants, 209 West 7th Avenue, Danver, CO 80204 (telsphone: 303/573-7882). (6)

## **AGU Job Center at Spring Meeting**

AGU will initiate a Job Cantar for the banefil of regis-Iranta and prospective employers at the Spring Meeting in Baltimore. The purpose of this center is to lacilitate scheduling of injervisws between registrants seeking smployment end employers seeking qualified personnel to lill their job vacencies. Job descriptions of open positions will be posied on bulletin boards et the center. Employers plenning to atland the meeting should bring job descriptions for posting to the registration dask and fill out a form indicating when someone will be available for interviewing.

Job candidates ahould bring rasumes with them to the mesting. Resumss will be held confidentially but will be open for review by registered prospective employers. Job candidates can review the posted positions and sign up at the Job Canler desk.

Interviswing will take place from 9 am to 4 pm Tuesday through Thursday In Exhibit Hall A. Applications and job descripilons can be left at the Job Center in the Baltimore Convention Center from 8 to 4 Irom Monday on. SS

## **Hydrological Forecasting**

Proceedings of the Oxford Symposium April 1980

Over 70 papers of Global Importance

- Hydrological data acquisition for forecasting pur-
- Methods for forecasting hydrological vertebles (Including weter quality) Application of recent forecasting techniques, particularly their euccess end their limitellone

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### Penrose Conference on Antarctica

A Penrose Conference acheduled for April 11-16, 1982, will locus on the globel aignificance of the Anterctic plate. Sponsored by the Geological Society of America, the conerence will be held in Shenandoah National Park, Virginia.

Antarctica is central to several problema of global geologic eignificance, including the processes of continental fragmentation, as exemplified by Gondwanaland breakup; the nature and development of the present Antarcilic plate; the plate'e configuration and intersction with adjacent plates during the late Mesozotc and Cenozoic; and the development of Southern Ocean circulation and paleoclimatic change. The purpose of the conference is to bring together scientisis from many disciplines to addreas these probisms.

Registration lee for the conference: approximately \$350 per parson. Special travsi errangementa will be made from Washington, D.C. Attendance at the conference is limited

For an application or additional information, contact elther of the convenore: Ian W. D. Daizell, Lamont-Doherty Geologicsi Obsarvstory, Columbie University, Palisadss, NY 10964, or David H. Elliot, Inetitute of Polar Studies, Tha Ohio State University, Columbue, OH 43210. Application deadline is November 1. 85

#### Rock Mechanics Symposium

The Massachusetta Institute of Technology will sponsor the 22nd United Sistes Sympoelum on Rock Mechanics, June 29—July 2. Designed for geophysiciets, civil and pstrolsum engineers, and rock physiciste, the conference will include papers and discussione on energy, mineral extracilon, civil construction, and wests disposal. Among the topics to be discussed are heat and fluid flow,

iregmentation and fracture propagation, deformation of rock massee, and site characterization. Field trips will be conducted through Boelon's Red Line

subway extension tunnel as well as through the Seabrook Nuclear Power Station cooling water tunnel.

For additional information, contact the seminar office at 617/253-7481, or write to Barbara Dullee, Coordinator. Center for Advanced Engineering Study Seminars, MIT, Cambridge, MA 02139. 38

### Solar-Planetary Relationships

SPR—Cosmic Roys and SPR—Solor and Interplanetary Physics

### A Celebrotion of the 25th AU Crossing of Pioneer 10

Ploneer 10 was launched in 1972 to perform the first flyby of Jupiler and the first exploration of the distant heliosphere. In celebration of Pioneer 10's 25th AU crossing, the principal investigators on the heltosphene investigations—J. Van Allen, F. McDonald, J. Simpson, E. Smith, and A. Barnes-will review their latest results in a special symposium to be held on Tuesday Aflemoon in room 310.

### Solor Flore Porticle Composition

One of the latriguing results in recent years is the anomalies and the systematic variations observed in the composition of energelic particles in solar flare events. In a special session on Wednesday morning, E. Slone and G. Mason will review recent observations and theories for the composition in flare events, and a variety of contributed papers will be given on current work in this field.

#### Solor Flore Porticle Acceleration

A problem of longstanding and current interest is the mechanism responsible for particle acceleration in solar flare events. In a special session scheduled for Wednesday morning. P. Sturrock will review the current status of theories of particle acceleration in flares, and K. Frost will summarize the results from the Solar Maximum Mission A variety of contribrited talks will be given on recent experimental and theoretical

#### Wovea and Turbulence in the Solor Wind

The solar wind is an ideal laboratory in which to test our unilerstanding of the properties of waves and jurbulence in a large scale astrophysical plasma. In a special session scheduled for Thursday afternoon, C. Sonett will review recent observations of waves and turbulence in the solar wind, and A. Barnes will review the current theoretical understanding. A variety of contributed talks will be given on recent experimental and theoretical results.

### SPR-Aeronomy

Spectroacopy in Geophysics On the Centenory of Rowlond'a Ruling Engine of the Johns Hopkina University

Baltimore is the home of the Johns Hopkins University. famous for its School of Medicine, but also known for its alumni who have made significant contributions to modern day geophysics These include, for example, Edwin O. Hall Idiscoverer of the 'Hall' effect while pursuing his Ph.D. back in 1879) and Henry Rowland (inventor of the ruling engine a century ago). Rowland's engine ellowed grating spectroscopy to be developed into a technique now used in a variety of disciplines ranging from the earth's etmosphere to astrophysics. A special session commemorating the centenary of Rowland's invention to scheduled for Monday. Following an introduction by W. G. Fostle (Inventor of the Fostle-Ebert spectrometer) on the legacy of Rowland, a series of Invited and contributed papers will review the contributions in grating speciroscopy in aurora, the atmosphere, the magnetosphere, the sun, planets, and comets.

#### Atmospheric Chemistry

A series of four sessions on atmospheric chemising (sponsored by SA and MI is scheduled for Tuesday end Wednesday, May 26 and 27. The topics will range from the earth's surface, through the stratosphere, and up to the mesosphere and D region lonosphere. The session on Weilnesday morning will focus completely on the subject of ozone, perhaps the most critical ingredient in the earth's atmosphere. A series of 14 contributed papers will describe rocket, balloon, and satellite observations of nzone, and

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theoretical and model studies involving ozone. Ozone is o principal factor in the earth's climate and plays an important pari in human-society-produced pollution effects (namely as a barrier against some cancer-producing soler rays).

#### The Chotoniko Rodor

The powerful radar eystem located at Chatanika, Alaska, for the past decade has provided detailed measurements of densities, electric currents, and fields in the high latitude, Ionosphere, and atmosphere. These unique observations made on the earth's surface have been used in a wide range of correlative satellite, rocket, and surface experiments. They have made possible significant contributions to an understanding of auroral and magnetospheric processes. A special session will review the past contribution of the Chatanika radar and describe the planned move of this major acility to Greenland. The session is scheduled for all day May 28, and will include invited papers by R. R. Vondrak and J. D. Kelly of SRI and P. M. Banks of the University of Utah. T. Stockjiel Jørgensen of the Danish Meleorological Institute will review plans made for the Chatanika radar's future after it

#### SPR-Magnetospheric Physics

The magnetospheric section (SM) will be sponsoring four special sessions. Two will consist of invited papers for oral presentation. The other two special sessions will consist of contributed poster papers. The special poster sessions will be held Monday afternoon, but facilities will be available for authors to exhibit their posters all day. The scheduled poster papers include 11 in a special session on Waves, instabilities, and Turbulence in Space Plasmas and 10 in e special session organized by Joe Barfield, on Birkeland Currents. The use of posters on such o large scole in regular meeting rooms will be a new experience for many AGU participants. This method of presentation has been well received in other professional societies, and we hope that it will be equally successful in the AGU. Seven more poster papers will be presented in a 'potpourri' session Thursday afiemoon, following the SPR

On Wednesday morning there will be a special session of invited talks on the Auroral Polential Structure. The program of speakers for this session includes Dave Evans, Joe Fennell, Forresi Mozer, Larry Lyons, Y. T. Chiu, H. L. Rowland, and Bob Hoffman. The special session for Friday afternoon will feature five invited lalks and a period of open discussion on the extraction of Solar Planetary Date from History and Folklore. This is a novel topic for the AGU, and those who attend will be well rewarded by the broadening of their horizons. Speakers will include Bob Eather, George Siscoe, Asgelr Brekke (or Alv Egeland), Joan Feynman, and Sam Silverman. The Friday program also features 29 contributed magnetospheric papers on Jupiler, Saturn, and their satellites.

#### Planetology

#### Upper and Lower Atmosphere of Venus

A full day on Friday will be devoted to a discussion of the Venusian atmosphere. Presentations will focus on the structure and dynamic processes within the thermosphere, lonosphere, and lower etmosphere of the earth's sister plenet. These presentations will be based to a large extent on extended analysis of deta obtained by the Pioneer Venus spacecraft. Specific lopics to be addressed include variations betwaen the deytime and nighttime atmosphere, coupling of the upper atmosphere with the solar wind, spatial and temporal variability in the position of the ionopause, and the distribution of sulfur dioxide in the lower atmosphere. This session also contains a special report on the recent discovery of natural gain amplification within the infrared spectra of the Martian atmosphere.

### Geologic Processes on Icy Bodies

New address

New phone number.

OFFICE.

This special session is devoted to the icy moons of Jupiter-Ganymede, Europa, and Callisto. Presentations will focus upon the distinctive surface morphology of the bodies and various models that are being proposed to account for these features. Unique types of 'thin-skin' tectonic deformation and phreatic volcanic activity may occur on these icy bodies, where water ice is interred to be a major uent of the planet's crust. Cratering mechanisms on Jupiter's moons should also differ significantly from those that have operoted on the terrestrial planets. This special session, scheduled for Thursday efternoon, emphesizes the challenge of comparative planetary studies in treating geologic phenomeno that are clearly beyond our terrestrial experience.

## Meteorology Oceanography Geodesy

#### SEASAT

Five sessions (Monday, Tuesday, and Wednesday) will be held for presentation of Initial results obtained from the SEA. SAT satellite. Three sessions will be sponsored by oceanoge phy, one each by meteorology and geodesy. These sessing will cover analyses of data from the microwave radiometer, radar allimeter, scatterometer, and synthetic operture radar

#### Hydrology

#### Acid Roin

Acid rain has received considerable attention in recent years because of its effects on the environment. This session echeduled for Monday afternoon, will cover topics ranging from the effects of acid rain on aquatic ecosystems to the acid loadings from snowmelt. Recent development of long-range transport models will also be addressed.

#### Symposium on the Notional Urban Runoff Programs

A full-day program (May 26) on the National Urban Rund Program (NURP) will be followed the next morning by a feld trip to the urban runoff monitoring sites in Baltimore. The symposium will include an overall view of EPA's objectives in NURP, case histories, USGS studies, and designs of monitor

#### Woter: A Constraint on Synthetic Fuel Development

There will be brief presentations by speakers from the government, consulting firms, universities, and industry, who will also participate in a panel discussion. Topics will include the national, regional, and industrial perspectives, the water requirements for synfuel plants, available data, and a case study. This symposium, scheduled for Tuesday afternoon, su begin with two papers on the effect water availability has on the development of synthetic fuels.

#### John Ferria Sympoalum on Groundwoter Hydraviics

For more than three decades, as both a nationally and Internationally renowned researcher and teacher, John Fants has contributed to basic scientific knowledge and general application of principles of hydraulics to the solution of groundwater problems. During this period, the methodologies for a plication of hydraulics to solving groundwater problems have continued to evolve and improve. The development of and fer test techniques and anelytical solutions commonplacer the 1950's, '60's, and early '70's are now increasingly supple mented by the use of numerical models and automated parameter estimation techniques.

The purpose of this all day symposium on May 27 is locplore the broad application of hydraulics to the solution of groundwater problems through review of methods used in the last three decades and through presentation of the latest tesearch and sophisticated state-of-the-eri techniques.

#### Whot Geochemistry Con Tell Us About Bockground Weles Quolity

Geochemistry can be used as a tool to interpret water quality. On Thursday afternoon this symposium will explore controls on the phosphorus cycle, the prediction of caldum and magnesium concentrations in erid soil waters, chemical reations in groundwater, and controls on isotopic compositions of groundwater systems.

### Trace Organics in Groundwater

4 3

The least

More and more trace organics are being found in ground water. These organics often pose problems to the public health. On Thursday morning this symposium will explore some of these present problems and describe the history of organics in the groundwater of specific areas.

## Reloting Drinking Woter and Heolth: The Need for Dale

This special session focuses on the need for data banks to determine possible relationships existing between drinking ter and health. Existing data banks and storage and retrieval systems are presented, end the need for further data cole tion and enalysis systems will be discussed.

## GAP

#### Geotectonics Volume 14, Number 2, 1980

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International Ophtotitic Symposium (V Heid ophtotilic conference, Nicosie, Cyprus, April 1—8, 1979)

Aeronomy

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JA. Banton (Loorr sod Pisontsry Laboustory, Niterally at Alisons, Durano, Arimone 55721)

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## Electromagnetics

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Gerde, France) P. Broche, J.C. de Maisire end A. Fontenel This paper investigates the celationship bet-ween the frequency leatures of the directional spectrum of ocean waves (cutoff frequency and pack frequency of wind waves, frequency of quest monochrometic amail) and the properties of the apectrum of the sea etho obtained by MF Doppter radge.

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A theoretical analysis is performed to theck the validity of a simple result that states that at upper Rf, a long-wave spectral feature at frequency fg, affects the radge echo at iraquentles tig tig on either side of the Brage lines at zig corresponding to resonant backscattering of reducewes with a given wavelength by half-wavelength ocean wavels. of redio waves with e given wavelength by half-wavelength otens waves.

An experiment using both cedae and slanderd in-slu wasaurements for severel weeks at dif-ferent times of the year shows that this reletionship can be used to formulate a method for estimating the frequency forturet of the aea with suitable accuracy.

Rad. Sct., Paper 180450

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## **Exploration Geophysics**

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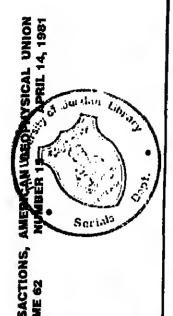
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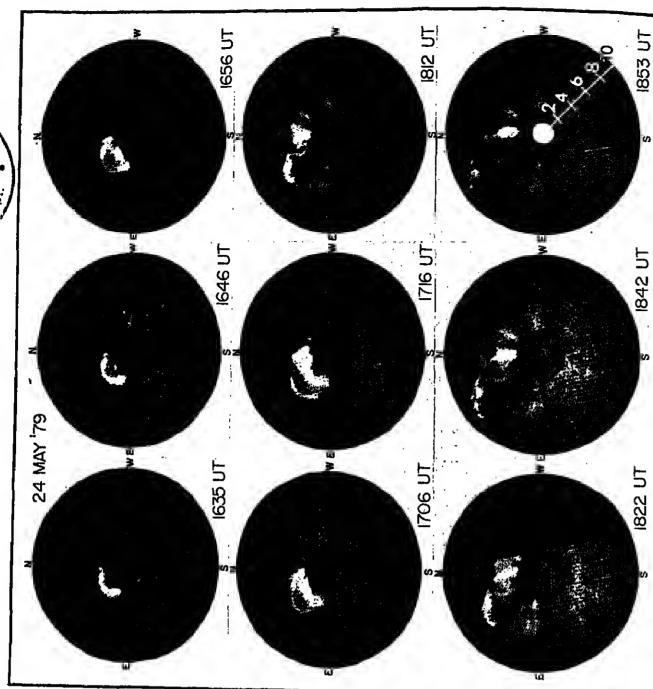
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APRIL 14, 1981

## Geochemistry

i. F. Vaddas (MASA Ames Resease) Centur, Maffatt Fisio, CA 940191 E. C. Y. 188, S. J. Tyson, C. A.

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J. Gesphym. Ses., Gramm, Paper 103892

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#### Geodesy and Gravity

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D. Barby, E. Ryland (insitute of farth and
Plana Lary Physics, Spartment of Physics,
University of Alberta, (duponton, Lanade fon 231)
J. Sarvas, O. Charas and J. Gonzáles
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Est. Soudslupe Fectoria, Raja California Morte,
lantailed in late May 1980. Nah been resurveyed
To 30 maperiment that a tarted 12 hours ofter
the June 8, 1980 Yeltoria mertheusis, which had
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matheoria. The reservity max complets by June 13.

Both the initial observations and the reservary bera done with HPSB00 distance motor equipment. Some angular control was provided with a bild 73 thacdolits. The notwork underwent a compressive strais of 7:3 wicro strain essentially parellal to the Carro Pristo foul about the lime of the serinquene. Strains of this size are associated with aimpie dislocation models of certhquenes of this magnitude. Its direction appears to be hademloss however. This may indicate compression retailed to soil liquefaction processes or strain near the end of the slip plane. Geophym. Res. Lett., Paper 118178

1910 Crestal adversents
600E11C STRAIN MEASUREMENTS IN MASKINGTON
J.C. Savega (U.S. Geological Survey, 345
Aldolaf laid Road, M/S 77, Amelo Park, CA 9025),
N. Lisomshi, and M.A. Prescoti
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crumulas iton in the hele of Neathington for the
interval 1972-79 are reported. Near Seattle the
average principal strain rhas are 0.070.00
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and near 9(called Coult Contral Mashington) the
average principal strain rhas here -0.0240.01
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and here measurement of their strain accumulation idilalaion not determined) in the spoch 1914-66
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model Inst Expression and are roughly consistent with a cread dislocation model Inet represents with a cread dislocation model Inet represents subduction of Ina Junn de Fuch plate. The observed accumulation of strate lepties that large, shallow, brest shripated should be spected off the coast of Mahilington and British Columbia. However, his concission is not shallow reconciled sish either observations of Sismition Champo along the Mahilington toall or the focal mechanism solutions for Shallow arthquakes in Mashington. (Saedelle inhabitation), J. Geophys. Se. J. Geophys. Res., Red. Paper 120295

1910 Crustal movements
1910 Crustal movements
1915 DETERMINATION OF DISPLACEMENT FIELDS FROM
GENOFIC CATA ALONG A STRIKE SLIP FALLT
W. Frencott (U.S. Geological Survey, 345 Aldole(Isld Road, Manie Park, CA. 94025

Observations of angles or determes between
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to infar information about the accessority used
to infar information about the accessority used
stations of the earth. The absence of any
observations schemel to the network leads to gn
subjusted displacement field. Existing
techniques of allumeting this arbiquity are
sali unsatializatory in some respect. The best
tachnique, an 'inner coordinate solution' is
not appropriate for natworks located in a static
solution serous the rotation of all stations
solut best content of mass. Along a static silp
fault like the San Ardress, however, solien
named to the fault.
The solution presented here, an 'outsa'
coordinate' coincion, finds the rotation of the
natwork that simisizes the components of
displacement named to the fault, its displacements
obtsigned with the outer coordinate solution are
locations.

Esamination of a sullotaration network near San Francisco Bay demonstrates the large direct that the choice of edjustment technique can have on the inferred relative motion of the avoides of the faels. The inner coordinate solution gave a rate of about 1 may year warses the preferred outer coordinate solution sate was 36 may year. en/year, J. Goophys. Res., Red, Paper 180307

3910 Crustal movements
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S. Cohen (Geodynanics Stanch, Goddard Space
Flight Center, Greenbelt, Mc 2077;
Fost satisfic surface deformations are etributed to the Instantic flow of the sub-crustal
regions of the sarth following an sarthquable.
In multisper representation of the earth's
readingical properties is used in conjunction
with a finite element computational schees re
calculate time-dependent displacements and
surains subsequent to a strike-slip earthquable.
The deviatoric attesses train relation for the
upper-conce layer is assumed slastic. Comes
layers are essumed to be, in order of instansing depths attended timent, three-sissent,
viatoristation colid; a linear viacoslastic fluid;
and another stastic solid. Frysically there
layers correspond to the upper lithophers.
Lower lithosphers, sathenosphers, and Lower
measile, respectively. Elastic dilettical
proparties are assumed throughout. Appealship postesiantic displacements, possibly
approaching meases for large corrhquable, sales
from the viacous lastic relaxation tollowing the
sudden coasfastic slip. Furthercore, compared
to the alapter case of an electic lithosphers
overs a viacouslastic anthenosphere the serotherier osse of an electic over a viscoelestic asthenosphere the mem-fault postesismic sherr eiraic is increased, by a factor of two or more in some cases, by by a factor of two or more to sees cases. The presence of a tipoclastic idear lithosphere. Also the duration of post-saisets straining is issuessed if the viscosity of the lower lithosphere is greater than this of the underlying satheosphere. The training is the underlying satheosphere.

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1930 Sigh-order harmonics of the gravity polaritis field
SAMPLING FINCTION AND FINITE ELEMENT METBOD
REPRESENTATION OF THE ORAYITY FISLS
H.F. Goonid: Deutsches Geochimbes Forechungs
institut, Entraitisturg, Archmetr 21, 5-5000
Minchem 2, M. Germany!
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sempling points on a sphere - is obown and dissuspiling points on a sphere - is obown and disstanding function anders for the gravity field
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Bha darth. Rey: Geoghya: Space Phys: Paper 186311

## The Enigma of **Lunar Magnetism**

L. L. Hood

Lunar and Planetery Leboratory The University of Arizona

#### Introduction

The results of the Apollo program have given us an intriguing but very inedequate glimpee of the pervasive mannelization that cherecterizes the luner cruet. Returned sample studies, eurface magnetic field investigatione, end analyses of orbitat messurements heve provided useful constraints on the neture of the megnetization, but in retrospect. more questions have been reised then have been answered.

Parhaps the single most important of these questions conceme the origin of the magnetizing field. A simple possibility suggested from the outset is that the moon once poesessed an intrinsic global magnetic tield which originated in a small, formstly molten Iron core. The existence of such a field, if verified, would have extreme implications for our understanding of lunar, and hence planetary, thermal evolution. However, cleer evidence for more than a superficially magnetized crust has not emerged from the deta enelysis. Thermoremsnent magnetization itself has been difficult to identify unambiguously in samples of the lunar regolith, perlly because of their complicated impact histories. Surface and orbital measumments show magnetic enomely eignetures epperently associated with surficial materiel, such as basin ejecte, and rol with deep-seeted structures as expected from slow cooling in the presence of a steady magnetic field. Alternative suggestions for the origin of the magnetizing field heve primarily involved to cet generation mechanisms. Ot these, these that employ impact processes to briefly but atrongly amplify the week interplanetery magnetic field seem most reasonable in view of (1) the obvious bomberdment history of the moon end (2) the essociation of some mapped enomalies with basin ejecte, to perticular, impacts of cometery bodies, which normally poseess terge partially lonized atmospheres capable of strongly compressing a weak emblent megnetic field, have been mentioned most in this context.

The purpose of this contribution is to briefly assess our current understanding of the neture of lunar cruetal magnetization, with emphasia on properties that may provide basic dues to its origin. Brief discussions of returned sample studles and surface megnetic field investigetions are provided (for general reviews, see Fuller [1974] end Dyel et al [1974] inspectively), but emphasia is pieced on orbital studies that have not been completely reviewed elsewhere.



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Cover. Lunar orbiter photograph of the Veh de Graeff-Altken region, on which have been superimposed circles which represent he surface locatione and sosie eizes of the stronger megnetic inomaly sources of the region [Hood et et., 1978b]. Also shown ere projections of the interred directions of magnetization for each touce onto the lunar surface. The projections are long or short, depending on the control of the co depending on the estimated dipole moment per unit eree, and angle made by each vector with the surface is indicated.

### **Returned Sample Data**

As deduced from a verlety of magnetic property experiments, the main magnetization carrier in luner rocke is meteilic iron elloyed sometimes with small percentages of nickel end cobalt [e.g., Nagste et al., 1972]. As ehown in Figure t (upperhelf), smong the returned eamples the breccles end solle ere signiticently more enriched in metallic iron than sre igneoue materiels such ee mere beealt [Houeley et st., 1970; Strangway et et., 1973a]. Moreover, es indicated in Figure 1 (lowerhelf), Iron grains within the breccies and soils are often in the single-domein eize range end therefore relein e much etronger magnetic remsnence then the multidomein iron in the becalts. Consistent with these properties, the highest levels of eteble naturel remanent megnetization (NRM), about 10<sup>-4</sup> G-cm³/g, were reported for some cleeses of breccles end aolis, while the mere beeelte were cheracterized by levels that typically emounted to  $2 \times 10^{-4}$  G·cm<sup>3</sup>/gor less. The stronger magnetiem of the brecciee and soils has been attributed to generation within these meterials of metallic iron during impacts. This generation takes place vie the reduction of iron oxidee end silicetes eiready present. Both impact-essoclated shock [Clsowski et st., 1974] and heet [Pesrce et st., 1972] heve been proposed se possible causel mechanisme.

Uncertainties in our knowledge of the generation of ferromegnetic meterial in lunar rock during impacts, together with the probably complicated impact histories of relumed luner semples, have made interpretations of the observed NRM, with reepect to the origin of the megnetizing field, much more difficult. Collinson [t 976] considers that the primery NRM of luner beeelt rock le most commonly thermoremenent magnetization (TRM), ecquired at the time of extrusion onto the surface, but that the primary NRM has been subsequently modified, sometimes severely, by impact shock. Fuller et ef. [1979] conclude that the observed magnetic properties of certain mere beselts are not consistent with a primary etable remenence of thermal origin and that a majority of the observed NRM is most probably a shock remement megnel-Izetion (SRM) ecquired during successive meteoroid impacts. These lesues ere obviouely of centrel importence in understanding the nature of the magnetization process, and additional efforts to resolve them ere underway at several

Whether the primary remenence is TRM or SRM, the problem of the origin of the magnetic field(s) in which the magnet-Izetion was acquired remains. Attempts to measure the amblent fleid intensity at the times of formetion of lunar samples heve been difficult and controversiel, partly because of experimental problems, partly because of the aforementioned complicated histories of the samples, and partly because of our incomplete understending of rock magnetism. Neverthelees, there is some egreement that fields on the luner surface of as much as one Oersted ere required to explain the observed NRM of al least some semples [Fuller, 1976]. Stephenson at al. [1974] consider that the required intensities are coneistent with the early proposal by Runcom et el. [1970] (and others) that e former global lunar magnetic field, generated by dynemo ection in a once active lunar core, is responsible for the primary NRM but that secondary magnetizations were leter acquired by poorly understood mechenisms. The differing NRM properties and peleointensity estimates obtained for subsamples of a single specimen have led Fuller et sl. [1979] to argue that e constant pleneterywide paleofield is unlikely end thei trenelent megnetic tields, possibly generated during impacts [Smke, 1977], would provide a more reesonable explanation for these properties.

Finally, mention should be made of the young (<200 m.y. old) soll breccle 70019 collected at the Apollo 17 lending site specificelly tor magnetic experiments. This sample exhibits NRM properties similar to those of other, usually much older, soil breccles; moreover, Sugiure et ef. [1979) succeeded in performing a Theilier-Theilier peleointensity test on the eample's interstitial gless component, obtaining a value of ebout 2500 y. Since the likelihood of a global lunar magnetic tield in the recent past is negligible, the two possible explanetions for this result, noted by the sulhors, are: (1) the eample was magnetized in a reletively etrong local remenent fleid (fields exceeding 300 y were delected at the Apollo 16 landing site, although no measurements were obtained at the Apollo 17 alte; see below); (2) the semple wee magnetized in a localized, transient magnetic field, possibly generated during the impact which produced the breccia.

As a first step toward extending the results of sample studles to infer large-scele characteristics of the magnetization, it is instructive to consider the intensities end directional behavior of local magnetic fields observed at the Apollo landing altes [Dyal et sl., 1974]. A minimal field etrength of 3.4 ± 2.9 nT was detected on the edge of the Imbrium besalt plein st the Apollo 15 ette, and a field of 36 ± 2 nT was detected et the Apollo 12 site on Mare Cognitum. Fields of 103 ± 5 nT and 43 ± 6 nT were messured at two locations separated by 1.1 km in the Fra Meuro region at the Apollo 14 site, and fields ranging in intensity up to 327 ± 7 nT were recorded near the Apollo 16 ette in the Descartee highlands. Rapid changee in field intensity and direction were observed along a 7.1-km treveree at the Apollo t 6 site.

The amail scales of the magnelic fields detected elong treversee et the Apollo 14 and 16 landing elles imply localized. near-surface sources. One interpretation of this finding is that an originally uniformly magnetized oruet has been shattered end elmost rendomized by impacts. Alternatively, if some or all impacts caused megnetization of successive layers of ejecta materiels, then the observed localization of remanent field sources could be due to superposition of layers with dif-

fering directions of magnetization. The wide renge in observed field inteneities at different sites implies a strong dependence of the crustal field strength on local geologic setting. The Apollo 14 and 16 sites, where the strongest fields were measured, are respectively domi-

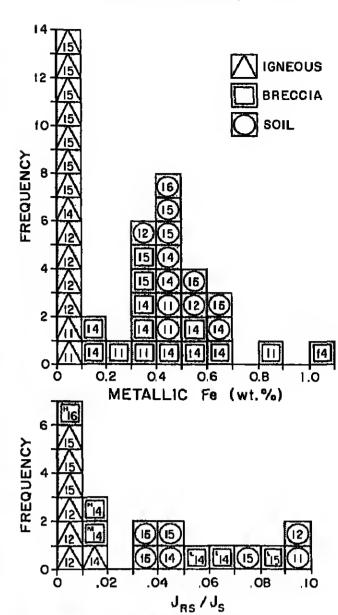


Fig. 1. (Top) Number of exemined samples with metallic iron concentrations in specified renges. The Apollo site number is indicated for each sempte. (Bottom) Same for retio of seturation remenent megnetization to saluration megnotization. [Alter Strangway

neted by the Fre Mauro and Cayley formetions. The Fra Mauro and Cayley units are interpreted by most analysis as primary and/or secondary basin ejecta, with all least the Fra Mauro produced at the time of the Imbrium Impact [e.g., Teylor, 1975]. The Apollo 12 and 15 landing siles are located primerily in erees dominated by mere baselt. These results together with the stronger elebte remanence exhibited by the brecclas end soils in reletion to that of igneous eamples, such es the mere beselts, led Strengwey et el. [ t 973b] to propose that especially coherently magnetized deposits of Caytaylike ejecta metenale ere likely to be mejor sources of lerge-scele megnetic enomelles that ere detectable from luner orbit.

## Orbital Magnetometer and Charged-Particle

Orbitel studies of luner magnetism began with the Explorer 35 miselon, which esteblished the negligibly low value of the global dipofe moment [Sonett et et., 1967; Ness et at., 1957; see elso, Ruesell et el., 1974] end indirectly detected cruatel magnetized regions via locelized compressions of the interplanetery megnetic field observed downstream from the moon [Bernes et el., 1971; Sonett and Mihelov, 1972]. The initial direct detection of cruatel magnetic enomalies with the Apoflo 15 subsateflite megnetometer [Colemen et al., 1972] led to en eventuel application of both magnetometer end charged-particle dete from the Apollo 15 end 16 subsetetiliee to the more deletted eludy of the distribution and properties of lunar eurfece megnetic fielde.

Much of the earfy mapping of the direct subsatelitte magnetomater deta wea reelricted to meeaurements obtained within the relatively undisturbed plasme environment of the geomegnetic tall lobes [Sharp et al., 1973; Russell et el., 1975, 1977]. Later mepping concentreled on Intervels when the moon was in the eofer wind but the Apotlo 16 subsetefilte was at e low altitude in the lunar weke [Hood et et., 1979a, b). The possibility of mepping the distribution of lunar surface magnatic fields via their reflection of energetic electrons was firel pointed out by Howe et el. [1974] and has been diecussed in further date if by Anderson et et. [1975] and Lin ef al. [1976]. Although the technique is indirect, it is complementary to the direct detection method because when the subsalelite was exposed to the soler wind or magnetosheath plasme, intervale are quite euliable for mepping, wherees the magnetometer dele from these infervats are not. Finally, e etudy of compressions of the interplanetary magnetic field that wee delected with the subsaleilite magnelometers in which the locations of several farge-scale magnetized regione were interred has been reported by Russell and Lichtenstein [1975].

Al leget perily because of the restricted coverage of early magnetic enomely maps produced from direct magnetometer measurements, the identification of major anomaly sources from this dela set was not swift. One correlation of e quasilineer surfece megnelization feature found in electron reflection data on the near elde with a long structurel rille, Rime Sirsalis, wee reported by Anderson et et. [1977], and quantitalive estimales of the magnetization intensities required to explein the enomely eccording to saverel possible models were mede [Srnke et el., 1979]. However, no film con-

Fig. 2 Correlation of nicolatively strong magnetic enomely lound in Apollo 18 eubsatolitte mognoto motor dato with o conspicuo us medium-albedo marking on wostem Oceanus Procellarum, known as Roinor Grimma [Hood of nl., 1079a].

clusions as to the most probable source of the observed enomely have been drawn (see also, Anderson end Wilhelms, 1979. Further thaight into the sources of large-scele anomafies camo when direct Apollo 16 subsetellite megneiometer dale that were collected et low altitudes over geologically lese complex areas of the near side were examined [Hood et et., 1979a, b]. Megnetic enomelles were found to be neerly nbsent ovor the weatern meria and over several large Impact crntore euch aa Copernicus and Kopfer; enomalies were, frowever, detected over exposed segments of the Fre Mauro Formation and over are es dominated by the Cayley Formation. These results represent alleast circumstantle evidence that levors Strengwey et al. 's (1973b) ejecta deposit hypothesis, based on returned sample and auriace magnetic lield deta. Further support ceme from a study of electron rellection maxima detected with the Apollo 16 subsatellite charged-particle instrument ecross the lunar far side in which the identified magnetized regions occur peripherel to large impact basins to arees where deposits of basin ejecte ere observedor interred [Anderson end Wifhelms, 1979]. This part of the orbital details consistent with a relatively simple picture in which eurliciet deposits of ejecte from large meteoroid impacts constitute a major portion of magnetized meterial on the moon. Such a picture does not immediately allow en identification of the magnetizing flefd(e), but the possible importance of impact proceases in either distorting an existing lerge-scale megnetic field or in generating short-

lived fields of the required intensities is deer. Less eesy to explein via such a simple model are the higher-amplitude enomelies detected with the subsatellite megnetometers and charged-particle instrumente. For many yeara, lhese anomaties were cited es poseible evidence for a tormer long-term lunar magnettzing fleld, aince it was eesumed that rather large thicknessee of crustal material (coolingover long time intervals) must be coherently magnetized to produce enomelies detectable et subsetellite altitudee. Some tight was cast on this issue when the strongest anomaty present in data from low-attitude pesses of the Apolio 16 subsatellite acrose the near side was found to correlate exactly with the location of a peculiar swirling etbedo merking on western Oceenus Procellerum, known as Reiner Gamma (Figure 2). The abaence of e detectable gravity enomely and the auperposition of the feeture on mere basalt flows, materi als thet ere elsewhere poorly megnetized, increesee the probability that the magnetic anomaly to due to a thin aurificial leyer of etrongly megnetized material. If the layer was deposiled during an impact, then it may have lormed and ecquired ils magnetization in a relatively short period of time. Thus, elthough other queeliona aro raised (including the inferred high magnetization level of the acurce tayer), the requirement and flord to produce strong cruste magnetic enomelies on the moon may be circumveniable. Simitar but much more extensive groups of Refner Gemmelype awirls have been identified on available photographs in highland torrain on the far side (Figure 3). Four of the arees where ewirls are most strongly concontraled are known to be nnomalously megnetic in reletion to a large fraction of the luner eurface [Lin et al., 1980]. Most of the areas of especialty intonse crustel magnetism detected with the Apollo subsatellites can now be associated with general concentrations of swirts, although a one-to-one correspondence has been demonstrated, because of coverage limitations, only for Reiner Germa

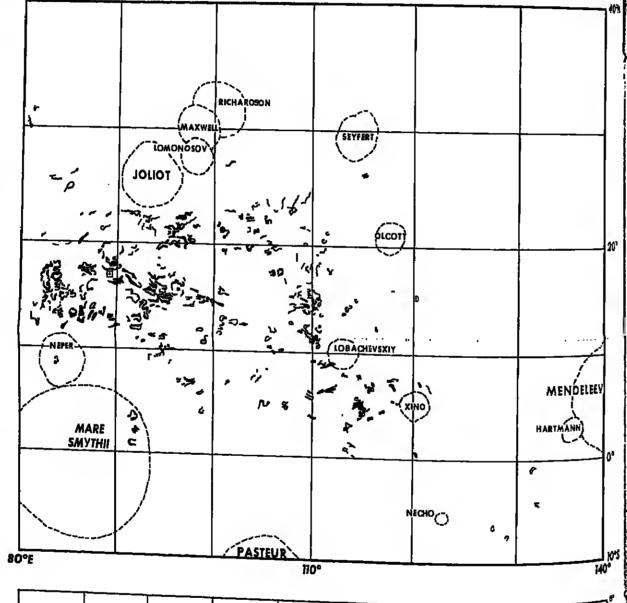
The geologic origin of the Reiner Gamma type swirts has been the subject of considerable debate, but the debate has not yell yielded egreed-upon constraints on the more general tssue of the nature and origin of lunar crustel magnetization. Hood et al. [1979b] proposed that Reiner Gemme consiste of unusually magnetic deposits of ejecta from eecondary crators of the nearby farge impact crater Cavaleriua (age: ~ 3.2 b.y.). Presorvation of the relatively high afbedo of Retner Gamme end some of the other swirfs (those that are essociated with impact craters older than about 1 b.y.) was ascribed to deflection of the solar wind ion bomberdment by the strong magnetic anomaly [Hood and Schubert, 1980]. However, Schultz and Smka | 1980| point out that the swifts often conlein dark fanes as wall as bright pallema, that the bright swirts

ere alrong lorward reflectors in contreat with most crater rays, end that et leest some of the swirls north of Mare Marginis appear to be essociated with the reletively young (late Copernican) creter, Godderd A. Therefore, as en alternative to the creter ejecia hypothesis, theae authore proposed that all of the swirls mey be all rongly magnetized residues of relatively recent collisions of the moon with one or more cometery comas. While cometery impacts may be viebte candidates for providing etrong magnetizing fields at the lunar surface [Gold end Sater, 1976, there are severel difficulties with the cometary impact proposel for the production of the swirls. These heve been noted by Hood [1980]. Other auggested mechanisms for producing the swirts, which predate the megnetica deta, heve been liated by Schultz [ 1975].

In addition to putting limits on the geologic nature and origin of magnetic anomely sources, orbital atudies using vector magnetometer data heve ettempted to determine, to a tirst epproximation, directional properties of the megnetization as well. A knowledge of the letter es a function of position in the crust would of course place severe conatreinte on the orientation(s) and scale-alze(s) of the lunar magnetizing field(a). Although source modela for a given megnetic anomaly are in many respects nonunique, several essumptions can be made that yield probable estimatea for the bulk direction of magnetizellon of the acurce. First, based on the severel correletione of magnetic anomaly maxima with surface geologic unlished above, it can be assumed that sourcea ere at or

near the lunar surfece; a reasonable source model is a triformly magnetized disk with a finite redius to be determined by a fil to the date. Second, in the case of relatively isolated anomelies it can be initially assumed that the surface position of the source is directly beneath the total field maximum detected from orbit. This assumption to exactly valid only with the direction of magnetization of the source is precisely veg cal or horizontal, so in practice, small edjustments from the initial position are necessery in the model-fitting procedure

The only results reported thus far have been for a section of the lunar far side, in the region occupied by the craters Yan de Greaff and Aliken [Hood et el., 1978a, b]. As Indicated in the cover figure, it was found that adjacent source regions it the atudied eree ere most probably magnetized in very diferent directions. The only nonrandom characteristic of the inferred directions of magnetization claimed by Hoodetal [1978a, b] was a depletion in the north-south direction How ever, Runcorn [1978, 1979] hes calculated pole positions of an assumed internal magnetizing dipole thei corresponding the inferred magnetization directions. Surprisingly, beliefs: smell but etetisticelly significant cluatering of these pole pos tione neer 0° latitude, 90° and 270° eest longitude. Futher more, he tinds that the pole positions that correspond to the etrongesi anomalies, f.e., those whose magnetization drea lions were probably determined most accurately, are there etrongly clustered than the remainder of the pole positions. Runcom then concludes that the resulte are most consistent



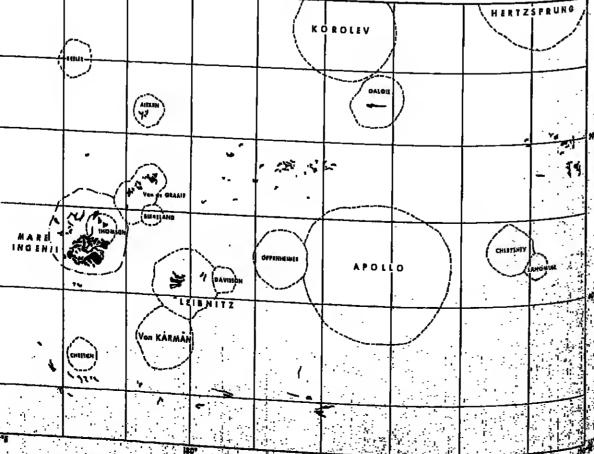


Fig. 3. Distribution of elbedo markings morphotogically similar to Reiner Gamma yieldie on available protograps of (e) the second in and (b) the central far side as mapped by Schultzerid Sinke (1980)

with the lunsr core dynamo hypothesis for the origin of the costal magnetization, although poler wandering by approximalely 90° must be simulieneously invoked.

Since the far-side region considered in the model-fitting analysis was localed neer 180° longitude, the ameli clusiering of pole positione near 90° and 270° found by Runcom implies thei the magnetizetion directions in the studied erea musl exhibit e small tendency to be more horizontal than verical. A reexamination of the inferred directions ahows that file is indeed the case ea can be seen, in part, from the cover ligure. The etrong north-eouth depletion of the inferred magnetization directions, logether with their fesaer tendency to be more horizontal than verilical, does not necessarily require magnetization by a global magnetic field. Specifically. a compression of the Interplanetary magnetic field (which normally lies parallel to the ecliptic plane) against the moon during impacte by bodies with pertially ionized gaseous envelopes [Gold and Soler, 1976] could leed to similar drectional properties. The highly inclined megnetization vectors required to explain observed anomalies on the fer side could be understood by superposition of enomaly sources during euccessive impacts.

An obvious way to distinguish between these two possibiffies la lo determine bulk magnetization directiona in other areas on line moon, preferably awey from 0° and 180° longilude. During the pael 2 years, contour meps of the subsalelille magnelometer data in several other regione have become avellable. Model-fitting procedures ere currently being applied to these deta.

#### Suggestions for the Future

The Apollo 15 and 16 particles and fields subsetallite missomewere not designed to map the dietribution of crustal magnetic anomalies on the moon. Although aome excellent data were fortunetely acquired within limited regions, optimization of orbit characterielice during e tuture miseion would provide significant increesee in coverage and resolution of both direct magnetometer measuremente end indirect election reflection measurements. Essentially, the orbit should be nearly poler with a low-eltitude (about 30 km) periepsis near the antisunwerd position. A polar orbit would provide elmost global coverage in contrast to the narrow equatorial bands sampled with the Apollo subsatellites. A 30-km pertapels ettitude is required to adequately resolve the crustel magnetic field and is approximately equal to the seperation between adjecent polar orbit tracks at the equator (the moon rotales about 1° during a 2-hour orbit). Location of the periepsia neer the antisolar position is required to minimize solar-wind-essocaled plasme disturbancee, which strongly affect the megnetomeler measurements. Because of the existence of crustal gravity enomelies, which led to the demise of the Apollo 16 subsalellile, and because of the tendency for the perlapsis to Mecess away from the anilsunward poeition, which reduced Reuselulness of most of the Apollo 15 subsatellite wake intavals, it is imperative that the spacecreft be capable of modtying its orbit from time to Itme during the intended mission

in combination with additional phologeologic etudies and other geophysical and geochemical measuremente obtained from the same spacecreft, such a set of data would place more decisive constraints on the origin of luner crustal magnetization. For example, if strong megnetic enomelies are associaled with other Reiner Gamma-type ewirts on the lunar far side that are demonetrably young, then the existence of transieni megnetic fields, probably generaled during impects. would be more clearly indicated. Alternatively, if other anomales are demonstrated to be associated with deep-seated structural featurea, then the former exietence of a globel lunarmagnetic field would become a more viable hypothesis, it s inportant to emphasize that more than one process mey have been responsible for generating magnetic fields at the moon's surface during its history and only when a complete gotal survey has been obtained will final conclusione ba-

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Lonnie L. Hood is a research associete et the Luner and Planetery Laboratory of the University of Arizona in Tucson. Ha received his Ph.D. In geophysics end space physics in 1979 from the University of Celifornie et Los Angeles, where his research work involved analysis of Apollo subsatellite magnetometer deta work involved analysis of reports subsequent that it is a first the direction of P. J. Coleman, dr., and C. T. Russell) and theoratical studies of electromagnetic induction in the moon and Mercury (under the direction of G. Schubert). Current research includes analysis of simulteneous Apolio 12 surface and Explorer instance data (in collaboration with C. P. Sonett and F. Herberi) and studies of problems relating to outer-plenet

## News

### **Space Transportation**

The U.S. space shuttle ushers in a unique flight research progrem Ihal supports NASA'a advanced (21st century) epace transportation program

The apece ahulile serves as e 'flying test bed,' carrying experiments to meesura orbiter flight performence paremeters during launch, booster, orbit, etmospheric reentry, and landing mission phases.

The flight recearch expartments will aid the development of concepts such as eingle-etege-to-orbit, heevy-lift launch vehicles end orbital transfer vehicles. These vehicles could deploy and service large, eutometed, human-operated, mullifunctional selellite platforme and an inhabited permaneni lecility in Earth orbit.

Two experiments, called the Orbiter Experiments Program, were included with the flight of space shuttle Columble. The Aerodynamic Coalficient Identification Package (developed by the Johnson Space Center, Houston) on board Columbie will collect aerodynamic dete during ett orbiler major liight phases. The Infrared Imegery of Shuttle (developed by the Ames Research Center, Mountein View, Calif.) experiment, located eboard a NASA C-141 alrerall. will gathor high-resolution temperature maps of the orbiter's Ihermal protection eystem during its maximum entry heat-Ing phese. The aircraft will underly the Columbia es it retums from spece for landing at the mission's end.

The results will advence aerodynemic theories, ground test methods, and other techniques used to predict end simulate performence of eerospece vehicles. The data will also be used to support verification of the current space shultle orbiter's design end to aid in evolutionary improvements to the spece shuttle. [Source: NASA]—PMB >

#### Extractive Metallurgy Program Funded

In an effort to concentrate research on ore dressing and metal production, the National Science Foundation (NSF) formed a new basic research program as a part of its Chemical and Process Engineering Division. This program will be under the euspices of NSF's Engineering Directorate. Research is to be supported on every step of extraclive metallurgy, from mining to processing to production. and even to reprocessing and disposat. Budgeting for the new program is expected to be on the order of \$1.2 million tor tiscal year 1981.

A progrem of this nature was apparently considered seri ously by the Carter edministration as a joint Department of Interior-private industry project of considerable size. Then-Secretary of Interior Cecil Andrus evidently did not support the program, but there is wide agreement throughout the mineral industries and the university community that such research is badty needed for the U.S. to compete. A joint program could benefit by cutting across the many difficult regulations that now are blamed for slowing research in

ninerals processing in this country. The newly announced program will probably be conducted es a collaborative effort between universities end industry, but under the NSF, il will be on e amailer ecale then thel considered by the Carter edministration. Director of the funding program, T. Mukherjee, plans e meteriels science approach. Metel production suffers in the United States by being energy intensive and generally tees efficient then in meny perta of the world. A strong research effort is needed and fits well in NSF'e new Engineering Directorate.---PMB

### **Dynamics Explorer Twins**

Two epacecraft that will ride piggyback into orbit next July are currently undergoing vigorous preleunch leeling at the Goddard Space Flight Center, Greenbelt, Md. Called Dynamics Explorer (DE) -A and -B, the twin salellites ere acheduled to be at acked togather and pieced into copisnar polar orbits by e Delta 3913 launch vehicle from the West-

em Spece end Mísalle Centar, Lompoc, Calif., on July 31, Their mission will be to explore the boundary region belween Earth and apace that affects the atmosphere, euroral deplaya, radio transmissons, and perhape climele end weathar. Solar rediation and the soler wind have e dynamic impact on the neer-Eerth environment, the results of which affect the stelle of the atmosphere, ionosphere, magnetosphere, and the more lamillar phenomena-weather, eurorsi displeye, end redio diejurbencea.

Prior apececraft, such as the Atmospheric Explorere, have provided new information on eolar radiation upon the . lower Ihermosphere and upper elmosphere. The ISEE (In-, Iemational Sun-Earth Explorer) program has provided addilionel new informetion on interactions between the solar wind and Earth'e magnetic field; however, adequate knowledge does not exist on the interactions between the two reglone. The Dynamic Explorer program is designed to aupply auch knowledge-specifically, the strong interaction processee coupling the hol, lenuous, convecting plaemas of the magnetosphere end the cooler, denser plasmea and: gases corolaling in Earth's ionosphere, upper almoaphere, and plasmasphere.

To eccomplian this, the project will provide a central deta proceeeing and analysis eyalem so that each investigator on the science learn can diapley geophysical deta from all spacecraft instruments. In their polar copianar orbite, one satellite (DE-B) will have a perigea sufficiently low (305 km) for neutral composition, temperature, and wind measure-

ils apogee will be sufficiently high (1300 km) to provide a

(News cont. on page 164)

200

(News cont. from page 163)

litatims greator then 11/2 yeers and to allow measurements sbovs the interactive regions for superthermations and plasma flow massurements of the megnatospharic tiald

The second spececraft (DE-A) will be pieced into a highly siliptical orbit having an apoges of 24,875 km to allow for globel suroral imeging, wave measurements in the middle of the magnetosphere, end crossings of euroral itald lines st severet Earth redil.

The DE-B (low mission) has six 3-cm-dismeter itsxible etem antennae 10 m long and e eingis rigid boom e m long. These externel antannes will collect data for the actantitic instruments on board.

The solar cell arreys mounted on the 136-cm-diamster epacecraft body will supply the estalitts with slectrical anergy that can be dailvered directly to the acientilic instrumanta or storad in nicket-cadmium batterias as required.

DE-A is epin stabilized; its pttch, or spin axis heving e epin rets of t0 rpm, while the DE-B spececraft is three-exis stabilized with its pitch axia controlled to continuelly point toward Earth's surface. Configurations of both spececraft are designed to minimize unbalencing torques created by atmospheric dreg encountered in space.

Tracking, commend, real-time, end recorded data with be provided by NASA'e Space Tracking and Date Network; the NASA World Wide Communications System, NASCOM; and the DE Operations Control Center at Goddard. (Source: NASA)-PBM 82

#### Antarctic Meteorite Symposium

The Sixth Antarctic Meteorite Symposium was held in Tokyo, Jepen, Fabruary 19 and 20. Sponsored by the Netional institute of Polar Research, the symposium brought Jepsnase scientists together with several Americans and two Chinese to diecuss current resserch on metsorites, smphasizing research on mateorites collected in Anterctics. The symposium, now an annuel event, owas ite origin to the recent auccees of Japaneee polar scientists in collect-Ing lerge numbers of mateorite specimens in the Yemeto Mountains, a program now successfully emulated by U.S. parties to the Alian Hills and adjecent regions.

Forty-seven papers were delivered oretly, primarily in Japanese (the abstract volume was printed in English), on eublacts that included location, field collection, and curetion ot specimens (6); classification and description of metsor-Itsa trom Yamato Mountains and Alien Hille (14); minarelogical and petrological studies (8); chemical and isotopic

etudies (8); exposure eges and terrestrial eges at Aniards meteorites (3); megnetic end other physical properties in end Chinese meteorites (3).

The contributions represented primarily the work of Jan nese scientiets (e small part of it in collaboration with with ers in the U.S.). The Jepanses program is strong in miss. elogicel-petrological invaeilgetions, with e email but growing number of geochemists and geophysicists participating by spite the minerelogical ekills of the Jepanese participants h Antarctic meteorite resserch, besic description of the Jee nese collection is not fer savanced. In part because of he magnitude of the collection (nearly 4000 specimens) but siso because there are few Japaness petrologists who pe viously have studied meleoritss. Efforts are being made to address that problem and to expend the Japanese Anlars tic Meteorite Progrem to Internetional status. As more so entists from outside Jepsn Issrn of the collection, the emount of reeserch reported et future Anterotic Melecrie Symposie will certainly grow. Intermellen on the Proceed-Ings of the 6th Anterctic Melsorite Symposium, delails of futurs symposie, and ceteloge of the Yemeto Melecifie Ca lection (compiled by K. Yenel) can be obtained from T. the gete, National Institute of Poler Research, Kega, liables ku, Toyko 173, Jepen.—PMB 83

# **New Publications**

Atmospheric Physics J. V. Iribams and H.-R. Cho, D. Reidel, Boston, xii + 208 pp., 1980, \$t5.95.

Reviewed by Franklin I. Badgley

3

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This compact book packs a great deat of information into its 212 pegee and presente it in a streightforward, comprehensible manner. According to the authors it is intended as a textbook for e university course at a second or third year level for etudents who have had a lirst-year general physics course end a knowledge of elementary methemetics. Judging from the content, this math should include a working knowledge of both integral and differential celculus. Some knowledge of chamleury is elso essentiat for understanding the meterial on thet subject.

The text le divided into seven chepiere entitled 'Gensrei Description, 'Atmospheric Chemistry,' 'Redietion,' 'Atmospheric Thermodynemics and Vertical Stability," 'Ctoud Physics, 'Atmospheric Electricity,' end 'Almospheric Dynamics.' As the eulhors point out, the sections on chemistry end slectricity ore somewhot unorthodox but mey appeet to instructors of certain courses or may be omitted it

The meterial is well handled, end cartain topics such as rediction and etmospharic electricity are presented as cleerly and es conciesty es is possible et the level tor which they are written. Less satisfectory te the final chapter on stmospheric dynamics which attempts to cover motions of ell scales, from global to micro, and from both mathemetical and descriptive viewpoints, in 47 pages.

Particularly, in the first part of the book, some important equations are given without derivation, for example, the relationship between etectron number concentration and reflection of slectromegnetic wevss, the Cleuelue Clepeyron equation, Planck's lew, end releted lews concerning blockbody rediction. It is improbable that the etudent with tha preparetion specified above would have encountered these previously so it is a metter of pedagogical preference as to whather to strese the implications of these laws without invastigeting their sources, as the present authors do, or to cover less material with more stress on derivations. In other inetances, such as the darivation of expressione for dry end eetureted adiebatic lapse rates and of the equations of motion and continuity, the mathematical developments are mede concissly, understandebly, end with a suitable bland

of physical insight and methamatical approximation. Numerous questions and problems are given at the end of each cheptar, some easy, some chettanging enough to offer teachers and students a means of enlarging the chapter contant. There seem to be few errors. A good bibliography is given. Answers to some of the questions and problems ere included. One subject that is not treated but which would fit well with those which ere included is etmospheric

tt is difficult to know for just what type of eudlence the book would be exactly suited. It le definitely not for the caaual arts or lisereture etudent who wants easy access to eoms knowledgs of the atmosphere, nor in this reviewer's estimation is it the best choice se en introduction for e person intending to specialize in the field, eithough it could be edepled to the letter uss. Rather It would most closely meet the requirements of e student well trained in basic science and meth who intende to epscistize in some field such as engineering, setronomy, or oceanography and who wents more then a cursory ineight into the physical nature of the atmosphere, its solved and unsolved problams, end that techniques available for ettecking them. Anyons contem'80 Shelf Edition of EOS Is BIGGER than everl

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Franklin I. Badgley le with the Department of Amospik ic Sciencee, University of Weehington, Seettle, Washington

physics through research. Preference will be given physics through research. Preference will be given to a sciential whose specialty is selemic properties of earth materials and who has selemic properties of earth materials and who has selemic properties and schultz Professor will provide leadership and guidence in establishing a quality tacohing and remarks exploration geophysics group. The University of Ckighoms has recently made a strong comant to the earth actences with the establishment of a College of Oeosciences, to be housed in a new building. The School of Geology and Geo-physics will expand from its present faculty of 18 to 28 laculty members by 1888. This will include three adenties in the exploration geophysics area, five in structure sectionophysics-eqlid earth geophysics and others in stratigraphy-peleoniclogy, geochemistryperiody, and energy resources.

Applications are true April 30, 1981, Inquiries, northelians, and applications should be sent to John Wickhem, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK

Exploration Geophysicist/University of Oklahems. The School of Geology and Geophysics of University of Oklahoms will hire an expe-

renced exploration geophysicial to till the Frank end Betty Schultz Professorship, and is seeking naminations and applicatione for the position. The

perinations and appressions for the postdon. The person must be a distinguished actantist who has made important contributions to exploration geo-

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issociate Professor/New Maxico Etete University. Geophysics at NMSU is an interdisci-pleary program between the Oepartment of Physis and the Department of Earth Sciences with en amphasis in exploration geophysics. We are seek-ing an additional lenure track faculty member with a round in either seismica end seismology or electrical and electromagnetic methods. The successful candidate will be expected to teach upper dision and graduate courses, conduct research and to supervise graduele students' thesis and dis-setation research in the candidate's area of experise. The appointes will also be expected to teach hishman and sophomore lavel courses in either

physics or geology.

klinimum qualifications include an semed doctor tis in peophysics or a closely releted eras and dencretrated research capabilities. Tasching expe-nence and a proven ability to secure research fundleitnesse too tud eiderlash av on

The expected satery range for this position is \$25,000-\$26,000 for the nine-month academic

opications and lattere from at least three refer should be submitted by Mey 15, 1981 to el-the: Dr. Russell E. Clemons, Heed, Department of Earth Sciences, Box 3A8 or Dr. Auguel Miller, Head, Department of Physics, Box 3O, Las Cruces,

New Mexico State University is en effirmelive acbon'aqual opportunity amployer.

Faculty Pasition/Atmospheric Sciences. The University of Artzone has an opening for a serve track leculty position in the Oepartment of Amospheric Sciences. The appointment can be take up to and including the rank of associate pro-Msor. Some preference will be given to candi-date with specialization in one or more of the following steas: sympotic meleonology, salelitle meleo-roopy, boundary layer meteorology, air poliution, and sir-sea interactions. The applicant must have In samed doctor's degree in the simespheric aci-ince or a releted discipline. Applications will be accepted until August 1, 1981. Appointment can be elective as serly se January 18, 1982. The candi-dis must have a dedication to undergraduate and graduate leading and is expected to develop a ign quality research program. Interested individ-ute should submit a complete curriculum vitee, a fix of publications, a statement of teaching and re-team leasons. ch interests, and three letters of rec on (sent directly by the writers) to Louis J. Sattan, Head, Department of Almospheric Solences, Uni-versity of Arizons, Tucson, Arizona 65721, Phone (802) 626-1211

is University of Arizona is an aqual opportunity/ firmative action amployer.

exas Tech University: Feculty Positions. The Department of Ocosciences is seeking applications for additional faculty members in geoi-W. geophysics and geochemistry; applicants from fields of geology other than palaontology will be

These are tenure track positions at the assistent Assor level with appointments sterting Septem-

Applicants must have completed their doctoral programs, be interested in teaching at both the up depaduets and graduate levels, and have specific plate for research in their fields of specialization. Applicants for the positions should submit resumes the ames, the names of at least three persons from the department may request letters of recommendation, and brief description of research in-

I suity Position in Oceanography/Geole-in University of Northern Colorado. The Department of Earth Sciences Invites applications by a bit since

to a hit-time, tenure track laculty position in

Structurei Geolegist. The Department of Oeophysical Sciences invites applicants for e ten-ure irack structural geology position at the assistant or associate professor level, beginning August 1981. Ph.O. required. Safary commensurate with

Departmental equipment includes a digitizer, various geophysics equipment, and a remote sensing laboratory with an edgewise enhancer. The canddete will have the opportunity to substantially add to his or har equipment needs. Present computer scillies include a OEC 10 and ISM 360-44, while PK 3240 system with 16 megabyte capacity is un-

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est, and arranga to heve three letters of reference by May 1, 1981 to Or. Dennie A. Darby, Chairman, Ospartment of Osophysical Sciences, Old Dominion University, Norfolk, VA 29508.

University of Hawaii. The Hawaii institute of Geophysics of the University of Hewall Invite applicallon for tenure track positions available Juty 1, 1981. Applicants with specialties in any of the fol-

iowing fleide will be given coneideration:

1. Marina geophysics with emphasis in merina gravity and tectorics

2. Marine selamology

S. Marine magnetics
Applicants should have a Ph.O. degree end e demonstrated ability to conduct and promote me ring research. Ability to teach at all tevels is required. The position will be a joint one on en 11-month basis between the Hawell Inetitute of Oco-physics and the Oepartment of Geology eno Ocophysics. The appointments will be at the renk

Apply with resume and names of three reterences to Cheries E. Helsley, Director, Hewell fnati-tute of Geophysics, University of Hawall, Honolulu, Hawaii 9822, Closing date is Mey 15, 1881.
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#### Scientific Coordinator **Marine Operations** Lamont-Doherty Geological Observatory of Columbia University

The Lamoni-Ocherty Geological Observetory seeks a marine sciential-manager to coordinate and edminister merine operations. Duties inolude coordination of ectentitic programs and ships operations, budgetary and flocal monitor-ing, personnel assignment, meintaining scien-tilia equipment and providing technical support.

As coordinator, you will direct the operations of a lechnical support group and maine data re-duction and archiving facility. In addition, you will work directly with the Cheirman of Marine Geology and Oeophysics, but will coordinate the meine progrems of all research groups, as well as take the lead in the preparation of pro-posels to acquire lunds in support of facilities.

Qualifications include: 1; experience and/or training in MG&Q, 2) tamberity with MO&G instrumentation and equipment, 3) familiarity with research vessel operations, and 4) manage-

Applicants should submit resums of educations and work experience to: Or. W. J. Ludwig Acting Chairmen
Marine Geology & Geophysics
Lamont-Doherty Geological Observatory
Palleadea, New York 19964.

Headr Kerth Resources Branch, MASA Qeddard Space Flight Center. GS-1330-14/18: \$37,871-\$50,112 per emum, full-time per manent. The Earth Survey Applications Olivision Applications Directorate, NASA/Godda Flight Center Invites applications for the open position of Head, Earth Resources Granch. The incumbent of this position to responsible for planning. meneging, end conducting broad programs in earn resources remote senging peaks and eppined research and data analysis, emphasizing the devet-opment and demonstration of applications of remote sensing of earth resources from sorth orbiting satel-lites. The primery creas of research in the Snanch are land use management, vegetation actances includ-ing agriculture/forestry/rengeland and environment

monitoring utilizing remotely saneed deta and advanced technologies. Also, significant effort is dedi-

cations and scientific utility, end to apacification of date acquisition and information axtrection ayelems which best meet user eclentific and resource manin i needs. An edvenced degree in earth or physical sciences is required with education in the floring being epecifically proferred. Candidates should also have several years of progressively ance and management of remote sensing research programs and clear evidence of a atrong research beckground indicating senior resperch eclenite statum Resumes/SF 171's should be sent to:

Or. Robert O. Prico. Assistant Chief Eerih Survey Applications Division Code 820 Godderd Spece Flight Center Oreenbell, MO 2077 1 Ocadiine for applications is April 30, 1981.

## Ph. D. Scientist i or li

Will work for the High Altitude Observetory in the Soler Variability Section. As pert of a group, will develop theories of fluid dynamical and magneto-hydrodynemical turbulence end apply them to problems of soler and stellar convection zones and atmospheree. Examples: turbulent transport of momentum and energy, amplification and dissipation of magnetic fields, turbulent convection. Part of lime will be spent developing theoretical paremeterizations of turbulent processes which can be incorporated into global models of solar convection and the solar dynemo.

### REQUIRES (for level I):

● Ph. D. In Physical Science and strong training in fluid dynamics,

Demonstrated post-doctorel research experience in turbulence problems, preferably in a geophysical or astrophysical context.

 Research level knowledge of magneto-hydrodynamics and MHD turbulence.

• Willingness to apply turbulence theory to solar and stellar pro-

### **REQUIRES** (for level II):

Substantielly more experience beyond the Ph. D. Degree in turbulence problems, preferably in a geophysical or estrophysical context, which has resulted in significant independent research contributions appearing in publications.

Also desired, but not required (for level I and II): Demonstreted research experience in MHD turbulence problems, as evidenced by research publications.

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This is e three year term appointment which may be occupied 1 October 1981 or later. Send vilae, publication ffst, end e diecussion of reveient scientific beckground and how you would approech the solar turbulence problem to Margareta Domecki, NA-TIONAL CENTER FOR ATMOSPHERIC RESEARCH, P.O. Box 3000, Boulder, Colorado 80307, Closing dete is August 1, 1981.

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Geophysicist. Applications are invited for a tenure track position in geophysics for the 1981–82 academic year. The Ph.O. in geophysics or a closely teleted field is required.

Ws are seeking a candidate capable of teaching undergraduals and graduats courses and supervisundergraculus and graculus askinic exploration geo-ing graduate research in selsmic exploration geo-physics. Specific research interests need not be in physics. Specinic resources are encouraged from inclvid-that eree. Applications are encouraged from inclvid-Applicants should submit a resume and three let-ters of recommendation to Dr. Mold U. Ahmad,

Chairman, Ospariment of Geology, Ohio University, Athens, Ohio 45701. Ohio University is an equal opportunity/effirma-

Atmospheric Scientiat/Rediction Physicalist. Current Applied Research and Systems activities have created immediate openings in its fol-

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An extensive background in the numerical simulation of physical problems by use of mini and large computers is required. Candidates must have M.S. or Ph.D. in almospheric sciences or physical sciences. Both of these positions are renewable up to the steams.

Salary range is \$21,000 to \$35,000 per annum. depending on qualifications. Good Benefits, Qualified applicants should send three references, satery history and requirements to: Dr. O. P. S. Atland Applied Research and Systems 840I Corporate Drive

Feculty Opening. The Department of Geological Sciances of the State University of New York at Alberry Invites applications for a tenure track faculty position which will be available from September 1. 1981 at the assistant professor level for a research oriented scientist to join a department with strengths in structural geology, lectonics, geochemistry and petrology. Applications are invited from capicalists, capitalists and neachemists with Ph.O. degrees who feel qualified to complement or augment studies in these fields. Salery will be neoffable, Letters should be addressed to: Professor

gonable, Leners should be addressed to: Professor Kavin Burke, Chairman, Department of Oeological Sciences, c/o Personnel Department, State Univer-sity of New York at Albany, Albany, N.Y., 12222. SUNY at Albany is an equal opportunity/affirma tive action employer. Applications from woman, mi-norities end handicapped are especially welcome.

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Candidate should send resume, statement of research interest, and addresses of three references to L.D. McGinnis, Chelimen, Department of Geology, Northern Illinois University, DeKeth, IL 60115.

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Preferential consideration to candidates with a Ph.O. and land surveying registration (or in the process of getting such degree and registration); rank and salary are open and depend on the experience and qualifications of the applicant.

Send resumes, by 15 April 1981 in Head

Visiting Avaistant Professor. One-year, temperary position available August 1981 to lead mineralogy, general geology, and perhaps optical mineralogy. The auccessiuf candidate will be required to teach three courses during a two-series ler year; someone who anjoys teaching is needed. Persons on leave are anouraged to apply, Deed-line for applications is April 17, 1981. Please sent resume to David Krinsley, Depart Arizona State University, Tampe, AZ 85281. ASU is an equal opportunity employer.

Petrology/Geochemistry, University of New Brunewick. The Oepariment of Geology has a tenure track position available from 1 July. 1981, et assietant prolessor or higher level. The successful applicant will be expected to teach both undergraduatae and graduates es well as carries Out research and supervising graduate students.
This position is in addition to one currently advertland for a rook mechanic or peochemist

The applicant about have a background in pt trochemistry and petrology and should be prepared to teach in some aspects of petrology and geometric transitry. The successful applicant will be responsible for supervision of analytical sollities including an Y SI SI

an X.F.F.
Applicants should have a Ph.D. and preferably post doctoral experience. Applications including a curriculum vites and names of three refereed should be sent to P. F. Williams, Cheiman Department of Geology, University of New Brunswick.

Planetary Geologist. Tenure track assistant to associate professor position starting Sentential 1, 1961, or as soon as possible thereafter to teach 1, 1961, or as soon as possible thereafter to teach 1, 1961, or as soon as possible thereafter to see the planets. Research cases on Earth and other planets. Research about the planets represented the planets. casses on Earth and other planes. Present ahould be on understanding the physical process (for example, impact cratering, volcarism, testorilem) responsible for the origin of planetary sufficient, Applicants must have Ph.D. in planetary. Possible for applications is geophysics or geology, Deadlins for application

Donald R. Heragan, Chairman Department of Geosciences Texas Tech University P.O. Box 4109
Texas Tech University is an equal opportunity/si-

coanography, starting September 1981. We are steking a person with a broad background in coanography and one or more of the related earth behology. Major responsibility will be leaching behond and advanced courses in oceanography, courses in the related field, and general education courses. A modest emount of research is possible https://doi.org/10.1009/ph.j.degree or be in the final stages of completion on suppliers starting rank and salary will depend A that degree. Starting rank and salary will depend in experience and other qualifications of the candi-Applicants about submit a recurring and at least cost, chairmen, Optierment of Dr. L. Glen

# CONOCO

# **Electrical Methods** Research Geophysicist

The Exploration Research Division of Conoco inc. is interested in hiring a Ph.D. leval adentiat who is competent in ell aspects of electrical methode. The job will emphasize tha development of electrical methode in a research environment to obtain operational systems for solving real exploretion problems. The eppilcent should be cepable of hending flald equipment end be interested in the epplicationa, acquisition, end interpretetion as well as the theory of electrical methods. Applicants should submit e vita, officiel transcripts of ell college level work, and four references with phone numbers to:

Technical Assistant to the Meneger Exploration Research Division Conoco Inc. Ponca City, Oklahoma 74601

An Equal Opportunity Employer

1

#### MARINE RESEARCH SPECIALIST II.

Study transition metal end nutriant geochemistry in pore waters of deep sea sodimonts. Duties include nutrient analyals by eutoanolysor and trace matet snatyees by intomic obsorption epectrophoiometry end en aceenogiephic cruiae. Experience in enelytical chemietry, intereat in oceanography end geochemietry dosirebie.

Submit resuma end experience by Mey 1, 1981 to: Julie Fisher, Graduele School ol Oceanography. **UNIVERSITY OF** RHODE ISLAND Kingston, Rhode Island 02881. An effirmative action/equal opportunity employer.

Postdootoral/Reses roh Associats Posttions, The Johns Hopkins University, Applied Physics Laboratory, Positions are eval ble for studies of megnetosphericpling, hydromagnetic waves, end plesma instabilities in the lonosphere and magnetosphere The effected candidates will participate in the anelysis and interpretation of data from spacecialt and d-beard radars es well ea in the developmen end implementation of new ground-based and apacecralt studies. Positions ere for one year and ere ronewable. Tenure mey begin at any time through Saptember 1, 1981. Applications about be sed to Mr. Steven F. Sayre, Oept. AOI-15, The Johns Hopkins University, Applied Physica Laboretory, Johna Hopkins Road, Laurel, MO

An equet opportunity employer, m/t.

AGU/ASLO 'C'

John Meeting

February 16 19 1980

Soripps Remote Sensing Tutorists.

1 A. Ovorview of the Remote Sensing Facility— This one-day seminar discribes the deta bases, accucco and processing capabilities evalleble at Scripps Institution of Oceanography, Remote Sensing Fecility. A morning lecture with introduce pest, current end tuture space platforms available for observation of the Oceans. A brief discussion of where end how to eccess this information will conclude the lirst part of the class.

The attemcon will include e demonstration of processing and displaying imagary obtained from TIROS-N, NOAA-8 and NIMAUS-7. Classes will be held at the Helen Raitt Room StO Library on Monday, April 20, 1691 end Mondey. July 27, 1981, at 8:30 em. A nonselundable tee of \$50.00 must be aubmitted with the application. En-

2A. Users introduction to the Scripps Remote Seneing Facility—This lour-day workshop is intendively for individuals who will be using the lacility at Scrippa. Two morning lectures will de-scribe in detail the headware, software and personnel resources aveilable to oceanographers. Existing data bases, their characteristics, location, mode and cost of arcers will be covered. Gasics of Image processing will be introduced along with in-depth look at the interactive Digital Image Menipulation

System used at the SRSF. The two lectures will be followed by afternoon tab sessions which consist of hands-on exercises to tecility. The third morning will be devoted to trein ueera in realtime epacecreft trecking and deta record-

The remeinder of the 3rd day and the entire 4th day will be used to work with users on a one-to-one pasis. Attendese ere encouraged to bring their own digital lapse with deta of interest to them, which can be used during this lest partien of the work-

Classes with be held in the Helen Ralit Room Sign Library starting on Tuesdey, April 21, 1981 and Tuesdey, July 27, 1981 at 8:30 am. A lac of \$335.00 must be submitted with each application.

Enrollmant limit—6.
For more information regarding applications, less, etc., places contact University of California at Sen Olego, SRSF/SIO, Meli Code A-030, La Jolia Celliornia 62093 or (714) 452-2292

#### SUPPLIES

Rook Hemmar with pick head and leather hotater for \$19.00. This is \$8.00 below list price, write for tree cetalog "Geologic Field Supplies and Propecting Equipment". Western Hartiage, 101 S. Weshington St., Hinadela, IL 60521. Talephona (S12) 954-5228.

## Meetings

#### Ocean Sciences: AQU/ASLO Joint Meeting

A joint meeting of the American Geophysical Union's Oceanography Section and the American Society ol Limnology and Oceanography will be held February 16-19, 1982, In San Antonio, Texas. The El Tropicano Holel la headquarters la the meeting, with additional housing available at the St. Anthony and the Gunter hotels.

The Call lor Papers, soliciting contributed papers from AGU and ASLO members, will be issued later this spring. All abstracts must be submitted according to AGU formal and guidelines. The deadline for abstracts will be in Novembor. Information on publication will be included in the call for papera.

#### Special Sessions

Ocean Climate and Biological Productivity Connections Overview of Large Oceanographic Projects Biology and Physics of Gull Straam Rings Rolations Between Biology and Circulotton in Itie Gulf of

Gsological Effscls of Ocean Circulation Anthropogenic Inputs to the Ocean: Diverse Points of

Processes and Recources of the North Pacific Shelves Small Lake Limnology

Merine and Freshwaler Bioturbation Ocean-River Interaction: Sedimentation and Chemistry Particle Fluxes In The Weter Column and Benthic Bound-

ary Layer Relations between Mesoecala Physical end Biological Processes

Coastai Processes Biological and Physical Maasurement Techniques Microscale Procasses and Effects on Blota Physics and Biology of the Edgas

#### Program Committee

Convanors: Worth D. Nowlin, Jr., Department of Oceenogrephy, Texas A&M University. College Stellon, TX 77843, [713] 845-2947; Richard W. Eppley, Institute of Marine Resources, A-018, S.I.O. University of California at Sen Diego, La Jolla, CA 92093, (714) 452-2338 (office), (714) 452-3194 (secretary).

Members: Charles D. Hollister, Woods Hola Oceanographic Institution, Woods Hole, MA 02543, (617) 548. 1400: Peler Jumers, Ocean Science and Technology Divieton, Office of Navel Research, 800 N. Quincy Street, Arlingion, VA 22217, (202) 698-4590; Cleire Schelski, Great Bonnio Steel Boulevard, Ann Arbor, MI 48109, (313) 764-2422; end Karl Tureklan, Geology Department, Yale Universily. Box 2181, Yalo Station, New Haven, CT 08520. (203) 436-0377.

#### Housing

Et Tropicona Hotet Single \$37 Doublo \$47

St. Anthony Hatol Single \$44 Doublo twin \$60 Double double \$80 Additional person King \$78

Gunter Hotet Single \$35 Doublo \$41 \$5.00

It you ere not an AGU or ASLO mamber, write Meelings, AGU. 2000 Florida Avonuo, N.W., Washington, D.C. 20009 end ask to be placed on Ocean Sciences Joint Maeling mailing list. 🕏

#### Erosion-Sedimentetion Processes in Mountainous Terrain

The apectrum of processes influencing erosion and sedimenietion is greatly enlarged in mountainous ereas ee compared to lowlends. Accordingly, much of the knowledge gained from etudies on lowlands has limited explication in: mountainous regions. A symposium to review erosion-sedimenietion processes in mountainous terrain is scheduled

for the 1981 Fell Meeting of the American Geophysical Union. The meeting will be held in San Francisco during the week of December 7-11, 1981. Four major areas of inleresi will be considered: (1) surface erosion proceesea; (2)

or combinetions of processes or modeling of responses will be considered. A copy of the abstract must be sent to the symposium chairman by August 15 at the following address: Walter F. Megehan, Forestry Sciences Laboretory, USDA Foreal Service, 318 Eesi Myrtle Street, Bolee, ID 83702.

mass erosion processea; (3) channel processes; end (4) ef-

fects of land usas. Papere dselling with individual processee

Detalfa regarding the meeting and the submission of abelracts will be announced in Eos in June; aimiler information can be obtained by writing Fall Meeting, American Geophysical Union, 2000 Fiorida Avenue, N.W., Washington, D.C. 2000g.

An original and two copies must be sent to AGU et the above address by the Fell Mseling Abetracl deadline-September 16, 1981, 35

#### Reinwater Cistern Systems

The University of Hewall's Water Resources Research Canter and AGU will coaponsor the International Conterence on Rainwaler Cistern Systems, scheduled for June 15-18, 1982, in Honolulu, Hewall. The objective of the conlerence is to gether past and current knowledge of reinwater delerns, including rainfell analysis, catchment area, storage cisterns, weller quality control, water use policy, and risk enalysis. Also to be included are diacuasiona of urban water manegement and the impacte of claterns on eoclety, the environment, end enargy conservation. Integralion of the rainwater cistem eyelems with extating weter

eupply and storm dreinage systems will also be explored. For edditional intermation, contact Yu-Si Fok, General Conference Chairman, Water Resources Research Center. University of Hawell, 2540 Dole Street, Honolulu, HI 96822 (lelephone 808/948-7298). %

## Hydrometeorology Symposium

The American Weier Resourcea Association will sponaor an Internetional symposium on hydrometeorology on June 13-17, 1982, in Denver, Coloredo. In addition to peper eessions and panel discussione, poater sessiona and field trips are planned. An exhibit of informational hydrometeorology equipment, books, end services is also expected.

The technical program will cover droughts, flood lorecasting, climatic irends, weather modification, acid precipitation, conflicts in hydrologic/meteorologic enalysee, end hydromeleorological especis of energy development. Offered end invited papere will be included in the progrem.

Additional details on the symposium may be obtained from General Chairman A. Ivan Johnson, Woodward-Clyde Consultenis, 2909 West 7th Avenue, Denver, CO 80204. 88

## Petroleum Colloquium

The Canedian Pelroieum Association will sponsor Colloquium III on Petroleum Mapping and Surveys in the '80'a in Benff, Alberte, on October 14-18.

On the session agende ere discussions of current special eurveying lechniques, present end future lechniques for navigation and offshore positioning, new techniques for mapping end cherting, federal government eurveying end mapping developments and requirements in the coming decade, and the impact of new scientific mapping end surveying developments on the petrolsum industry.

To receive edditional information about the collection, or to register in advence, write to Liz Hempton, Canadien Pe-Iroleum Associetion, 1500, 633 Sixth Avenue, S.W., Celgary, Alberte, T2P 2Y5, Cenada 88

## AGU

### **Membership Directory Corrections**

Please note the following corrections or omissions iron the Membership Directory published in the Novamber 4. 1980 Eas.

Benedito P. F. Breie, Jr., Department de Hidraulica-EPUSP, P.O. Box 8174, Sao Peulo, SP, Brazil 05568, @

Robert F. Cockerham, U.S. Geologicel Survey, Mai Stor 77, 345 Middlelleid Road, Menio Park, California 94025. (M-70-T). Stephen A. Cooperman, Depertment of Earth/Space Sci-

encea, University of California at Los Angelss, Los Angels lee, California 90024, (O): 213-825-4363, (H): 213-893-8249, (S-79-P). Irene Fischer, 301 Philadelphia Avenue, Takoma Park

Marylend 20012, (F-56-G). James T. Peterson, NOAA, RL3-335, 325 Broadway. Boulder, Colorado 80303, (O): 303-497-6866, (H): 303-53 4695, (M-79-M).

William W. Sager, Hawall institute of Geophysics, 2525 Corree Road, Honolulu, Hawall 96822, (O): 808-948-8972 (H): 808-948-7456, (S-79-GP).

Gordon S. Siewart, Selemological Laboratory, Callomia Inetitute of Technology, Pasadana, California 91125, 222 796-6811, X2958, (ST-75-S).

William Thorderson, 1020 15th Street, 8G, Denver, Con rado 80202, (M-79). Michael A. Weissmen, Flow Research Company, 21414

88th Avenue South, Kent, Washington 98031, 208-872-8500, (M·79-O).

Those members who joined before April 1979 have sec ondary sections of Selamology and Meteorology awilched



## Tectonophysics

#### Large-Scole Thin-Skin Tectonics (cosponsored by Seismology)

Includes investigations and structural analyses of this structural style deformation in regions of both compressional and exercional sional tectonism. Geologic and seismic evidence for act collement style faulting and geophysical and geologic dia a ancient analogues will be discussed together with the question ol reactivation of decollements. Regional studies span the globe, including investigations in the Himalayas, Aleuten trench erea, big bend area of the San Andreas, Talwan, Tu key, the Alps, the Apennines, the Appalachians, the Codic ran fold and thrust belt, and the Basin and Range province. (A full day session on Wednesday followed by a brief busness meeting and beer.)

## Tectonics of Venus and Earth: A Comparison (cosponsored by Plonetology)

Ploneer Venus has provided earth scientists with their gitmpse of the surface of the serth's sister planet. Offer collected by the Pioneer spacecraft on the gravity field of the planet. nus and the composition of its atmosphere provide addition constraints on models of planetary structure and evolution Analysis of this data clearly indicates that there are some differences between current styles of global tectonic deposition on these transfers. tion on these two planetary bodies. This special session review the fundamental differences between the shuffler composition of Venus and the earth. It will also consider our models of febtonic and planetery evolution that have been proposed to been proposed to account for these differences. Specific topics to be discussed include maritle convection, isolate tectories, and continental nucleation and growth P.M.)

#### comprises the basement, as well as deep measurements of the rock mass permeability, heal flow, and state of stress in this currently tectonically stable Interior region. (Monday PM)

**Seismology** 

Adaylong special session Wednesday on New Frontiers in Farth Structure is devoted to the seismic transmission problens of anisotropy, scattering, and Q. The topics discussed include manife anisotropy and its geodynamic implications. apparent and real Q in the short-period passband, and in situ Omeasurements. The controversial nature of these studies should stimulate some lively discussions. At the special session on Refraction and Reflection, Tuesday morning the latest results from COCORP deep crustal soundings will be presented along with theoretical studies of wave propagation in oceanic structure and travel time inversions. A Monday afternoon sesson on Seismicity and Tectonics will leature a reassessment of the motion between the Caribbean and North American plates, based largely on seismological evidence. Also to be presented at that session is an asperity model for global variations in the modes of subduction. On Tuesday afternoon a session on the Seismic'Source will emphasize moment tensor representations of large earthquakes, with a particularly interesting paper on complex earthquakes modelled as two or more large events with different mechanisms separated in

Illinois Deep Hole Project (cosponsared by VGP)

Preliminary results of investigations in a privately drilled.

roninuously cored 1.6-km-deep drill hole in northern filinois

made evailable to the scientific community. This hole pene-

trated approximately 1 km of crystalline besement, affording

detailed studies of the petrography, chemistry, detormation

history, and isotopic geochronology of the Precambrian that

### Valcanalogy, Goochemistry, Petrology

#### Arcs and Ophiolites

This session will concentrate on geochemical and isotopic evidence concerning the origin of arc-related voicantsm, induding the relation between subduction and the chemistry of are volcanic rocks, and the origin of ophiolites. An important question addressed by several of the papers is that of the posstillty that ophiolites represent oceanic crusi from more than one geochemical environment. (Monday, A.M.)

### Kimberlites and Other Strange Bodies

This section concentrates on the petrology, geochemistry, and origin of kimberlites, but It also includes papers on carbonatites, ultramalle bodies, and xenoliths. The session should appeal especially to those who are interested in data and ideas concerning samples from deep-sealed environments. (Monday, P.M.)

### Precambrian Evolution of the Earth

The two special sessions on the Precembrian Evolution of the Earth will concentrate on the history and processes from the initial accretion to the formation of the continental crust. The origin of the earth will be discussed within the larger context of the origin of the solar system and evidence about formation from the study of meteorites. Subsequent topics to be discussed will include accretions, thermal evolution, convection in the primitive earth, chemical zonation and development, and age and development of continental crust. (Tues-

#### Silicate Meit Structure and Crystallization Processes in Igneaus Rocks

A tull day will be devoted to these special sessions. They will bring together workers in the fields of crystal chemistry and petrology to present review papers as well as papers discussing new methods and data. Topics will include the structure of geologically important silicate melts, methods of determining melt structure, applications of the concepts of melt structure to petrologic problems, processes of controlled crystal growth from silicate melts, effects of nucleation and growth on the textures and mineral compositions of igneous rocks, and solubility of volatile components in silicate melis. (Wednesday, A.M.)

#### Seafloor and Ocean Island Volcanic Racks

The source geochemistry and mechanisms of ridge crest midplate volcanism still remain mysterious in spite of a considerable body of data on rocks from these environments. The papers in this session will focus primarily on magma generation process at midocean ridges and geochemical comparison of MORB and volcanic rocks from oceanic tslands. Several papers deal with the geochemistry of aseismic ridges and iavas produced from subducted ocean crust. (Wednesday,

#### Isatope Geochemistry and Geachronalagy

This session will include a variety of papers of interest to those concerned with new applications and data on isotope geochemistry and tsotopic dating. Several papers will concentrate on diffusion of oxygen and strontium. New applications and interpretation of Rb-Sr and Ar 40/Ar-39 dating, new data on U and Pb isotopic varietions in single crystals, and lurther

developments in Re-187/05187 chronometry will also be topics of discussion. (Wednesday, P.M.)

#### Volconoes and Their Rocks

Two hall-day sessions are devoted to the description of circum Pacific and Pacific volcanoes, eruption mechanisms, and the geochemistry of volcanic eruption products from both oceanic and continental environments. Specific topics range from the mechanism of the 1980 eruption of Mt. St. Helens. through descriptions of volcente centers in Aloska, Guatemala, New Zealand, and Hawaii, to the geochemistry continental iavas from North America, Alrica, and India. Those interested in magma mixing and magma chambers will also find tood for thought. (Thursday)

#### Neat Papers About Plutonic Rocks

The session focuses primartly on the geochemistry and petrology of granites and granitic rocks from the eastern part of North America. Petrologisis interested in the origin of tonalites, nepheline syenties, and gabbros, however, will not be disappointed. (Friday, A.M.)

#### VGP Potpaurri

Among the diverse subjects covered in this session will be new evidence from New Mexico on the Irridium anomaly at the Cretaceous-Teritary boundary and the extinction of clinosaurs. Also included are a series of papers clealing with the problems of storing nuclear waste in the geologic environment and a paper discussing No and Sr tsotopic evidence on the oilgin of central American voicanos. (Filday, A.M.)

### Decade of North American Geology

During the 1980's, as a part of its contennial, the Conlogical Society of America is spousoring the Decarde of North American Guology. One of the principal goals at this project is the crention of a massive synthesis of the goology and goophysics of the North American Plate. This will be accomplished by means of a series of t:5,000,000 geoingic, technic, gravity anchrafy, magnetic anomaly, and linearment imps, and approximately 23 volumes of integrated information on regional gradusy. and geophysics. The activity will involve most major geological organizations on the continent, and products will appear throughout the decade.

A workshop devoted to discussion of plans for the volunies on the Atlantic Coastal Plain and Shelf, the Western Atlantic Ocean Basin, and the Eastern Pacific Ocean Basin is scheduled for Monday, 3-5 P.M., Room 348.

# GAP

## Electromagnetics

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Hess is RAIN DEFOLARIZATION

J. Finelloposies (Department of Electricial Inglinesting, National Tothnical University of Athons, 42, October 29th Avo., thrus-147, Uresco)

Otherwood electiomagnolic wave depolations in ferward propagation due to pretipingliae in a short isra period ionda to distribute stristitsily about some mosn finel of depolatization. Using a special ibidity depolarization model, we have sinjudite accidentation of the crost-pair including a secial control of expensive in the control of the accident and feund an appreximate and second of the crost-pair including all of the signal and feund an appreximate and the signal and feund an appreximate and including the control of the crost-pair including with a signal and deviation of exprecise of a sil the person of the crost-pair of the crost-pai

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in experimental verification of Lin's frestition model for rais attenuation sintistics with data taken from a terrestrial fall in Albonn. It presented. It [Dation as generation balloni on that Listing so encouraging indication that that model could be the appropriate one for radio paths in the Great alreader (Rain Strain), stalls (ca, prediction model).

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# Exploration Geophysics

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Greenbystes, Val., ib, No., 6.

0930 Seignir methods SYNTHETIC VERTICAL SEIGNIC PROFILS

S. Dantambain Dyser [Phillips Petrolson Company, 71-C PMC, Eartleaville, Ot 74005)
A tins-domain could has been developed for calculation of a synthatia vertical maisoir profile 1879) from a sonic log recorded in a borabular The SVSP has promen to be vertexely sensul to the deterpretation of saturate data since it allows the interpretation of saturate data since it allows the interpretation of saturate data since it allows the interpretation of the saturate of the saturate

Praviously, the synthetic salemogram terholous sileved acutyals of the sarth's response to the mautes pulse at the matters only. Sowers, the de-valopment of the SySP allows insight into the sevilopecet of the bys allow insign the saleulation the saleulation whose the response of the verb to the source palse at my depth point in the subsurface. For example, the systhetic solmonrum can be used to identify as event on the saleulam matter as a relative play, whereas, the SUST cannot only identify a sulriple, but not also about which path the source pulsate the teach teach the source pulsate the teach te

The SVSP can pine be used to auslyse the change The SVS can size be used to analyze the cheage is sharested of the source pains due to the layering affect of the asrth, for example, affects of a thin bud sepasses; to anoty amplitude seriations due to transaction lovens; and to examine the sylones of different sources pulse bendwiths on the first surface asiswogram, standard laterpreture gain superisuce in analyzing the SVS, many sora applications are expected to appear.

Osophysics, Vol. 46, So. 6

6910 Smiemic methods Res 0910 Computes applications C. J. Velsboor (Eheil Development Company, Bell-sire Essectch Cooter, P. O. Box 481, Houston, TX 37001

sire Seserch Coeter, P. O. Box 461, Houston, T. 77001)
A sedimentary saquence som quite sfrem be considered very freitfully as a discrete Natkov choic, wat these oan be described by a stochastic metric. Knowing this metric and the thickness probability distribations of the layers of the various parties parties lithologies, while assuming that their densities and walerlites are seronly distributed, and sepression the sledy of or the autocorrelation (on power spectrus) of the selemin terilection transpasse. This expression tas bring sot sessetis! characteristics of the power spectre; i.s., the low-frequency droop and its sleep. This then lead to the penallis artimation of some physical and sections of the relienting of some physical and section of the relienting of the sequence of the sequence of the section of the law the next to or addimentary eyels thickness. The case of a binary sequence, as the predocing and sequence of the sediments of the Gull Coast area and Riggia, is analyzed to destif. The theoretical results conform sell with flaid data and lead to the laterceting conclusion that lodged the matiestinn of the above sentioned persenters is population. Cophysies, Vol. 46, So. 6

6930 Salesis satheds
AM EXAMINATION OF THEE MOISE IN VERTICAL SEISHIC
POSFILING DATA
S. A. Mardage Principle Petroleum Company, 71-C
PRC, Bartlesville, OR 74004)
This vaves not sq coles that canonilages oppoint
and doingoing body unversement which are the fundasectal seises to data mandered in varietical Salessia
profiling, (YSP). In two quebers evertical seises is
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shown to be surfaced ground real, that puspis across
shown to be surfaced ground real, that puspis across
the wall head. Sacandary junk was soprem revealted in these YSP, date are the degressia geophone
tool leads not the bottom, of the brishols. Body
wave algrate and head aftern to breaks this seven

when they arrive at eignticent lepadance rootrasts in the borshole such as then are in casing diameter. Computer situalisted vertiral geophone arrays are used to reduce these tube mave, but such arrays estemate and illier body wave events unless minitering shifts are made on that the body wave algual occurs at the same two-way time at meth geophone station. Consequently, artual download vertital inches of the same two-way time at material vertical good phone strays are not an aliantive comes by which tube waves can be elicitated. Fover sparter topartoons of tube wave and compressional body musa events demonstrate that band-pass littles dasigned to aliantes tube were also supposes body wave signals. A simple but signative field technique for raduting tube waves is shown to be proper course offers.

offset.

Using velocity filters to retrieve upgoing mon-pressional symmus from VSP data heavily rontermic-nted with tubs wave online yimids to one example no spreament with marines managered reliactions what is supprignt to that obvaided from synthetic selec-grams calculated from log data recorded to whe grams coloniated revenues and addition vol. 66, So. 6

Og 30 Smismic methods
HODELEG OF THE ACCOUNTS WAVE EQUATION WITH THANSFORM METHODS
Sam OPIO Computer applications
Jaco Gazdes (IBW Scientific Center, P. O. Box
10300, 1130 Page Mill Road, Palo Alto, CA 94304)
Humariesi as theds are described for the signification of twess phenomens with application to the
modeling of solesir data. Two separata topics are
studied the liter desire with the solution of the
accountin wans equations. The second topic trasts
wave physicseans whose direction of propagation is
restricted within too degrees from a given smis.
To the mesoriesi well-do degree from a given smis. accounts when expertant as propagation is restricted within 190 degree from a given sain. To the neserfest vertood developed here, the wass field is advanced in time by uning standard time differenting acheses. On the other hend, computed by Fourier transfers weekeds. This approach to computing deficiefive ministers transfers wethods hecome evident when attempting to restrict prepasations to upward moving waves, s.s., to avoid multiple relactions. Constraints imposed so the direction to upward moving waves, s.s., to avoid multiple relactions. Constraints imposed so the direction of the wave propagation as artemptished sont precisely in the wavenumber downin.

The stor analysis of the significant shows that transcales areas are das mainly to time discretimation, such arrors can be limited by the choice of the time sisp. Fathaps the most significant error phanescone is tabled to Allestag. This becomes not insultant when a regime with streng valocity variations, it is shown that aliesing arrors can be limited by the choice of the pains width. The feasibility of these posing pathods is demonstrated on numerical examples.

0918 Beismic asthods
1872ESION OF REFERCTION DATA ST WAVE FIELD
CONTURNATION
Has 0910 Computer applications
Robert & Clayton (Stanford Exploration Project,
Department of Comphysics, Stanford University,
Sfanford, ch 94305) George A. Hebrikan
The process of wave squarion continuation (signation) is adapted for refraction data in order to
produce valcoity-depth moders directly from the tecorded data. The procedure consists of two linear
transformations: 8 slant sinch of the data producing
a gave field in the p - 7 plans which is then doneward continued only 7 = 0 as the imaging consisten.
The result is that the data wave field is linearly
framsformed from the time-distance domain into the
alternate-depth domain, when the astocity profile,
sen he saked directly. No traval-time picking is
involved, and all the data see present throughout
the invertibes.

The cushod is iterative because it is necessary to specify a valority lyactice for the continuation. The solution produced by a piwes iteration is used as the continuation velority function lor the next step. Coowspaces is determined when the cutrat wave ifsid lesges the sens velocity-depth function as was input to the continuation.

The method obvistes the problems assortisted with determining the savelope of solutions that are consistent with the observations, since the tire resolution in she date to traceformed into a depth resolution in she date to traceformed into a depth resolution in the alcomesen-dapth domain.

The cathod is tilustressed with several synthetic sumples, and with a refeaseline line recorded in the impatial Valley, Calliarnia.
Geoghysias, vol. 45, 80. 8 Gesphyales, Vol. 46, No. 6

0910 Setemic methods
FUNDAMENTALS OF FREQUENCY DOWNIN KIGRATION
JOONS N. Chum (Enlemograph Service Forp., P. C.
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Fraquency downin migration in founded upon the
wave equation, and so includes diffractions and
other affects. This paper same to motivate and
illusinate fraquency downin migration using
arreightforward geometric techniques and alupis
Fraquency downin observations. waphysics, Val. 46, No. 5

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